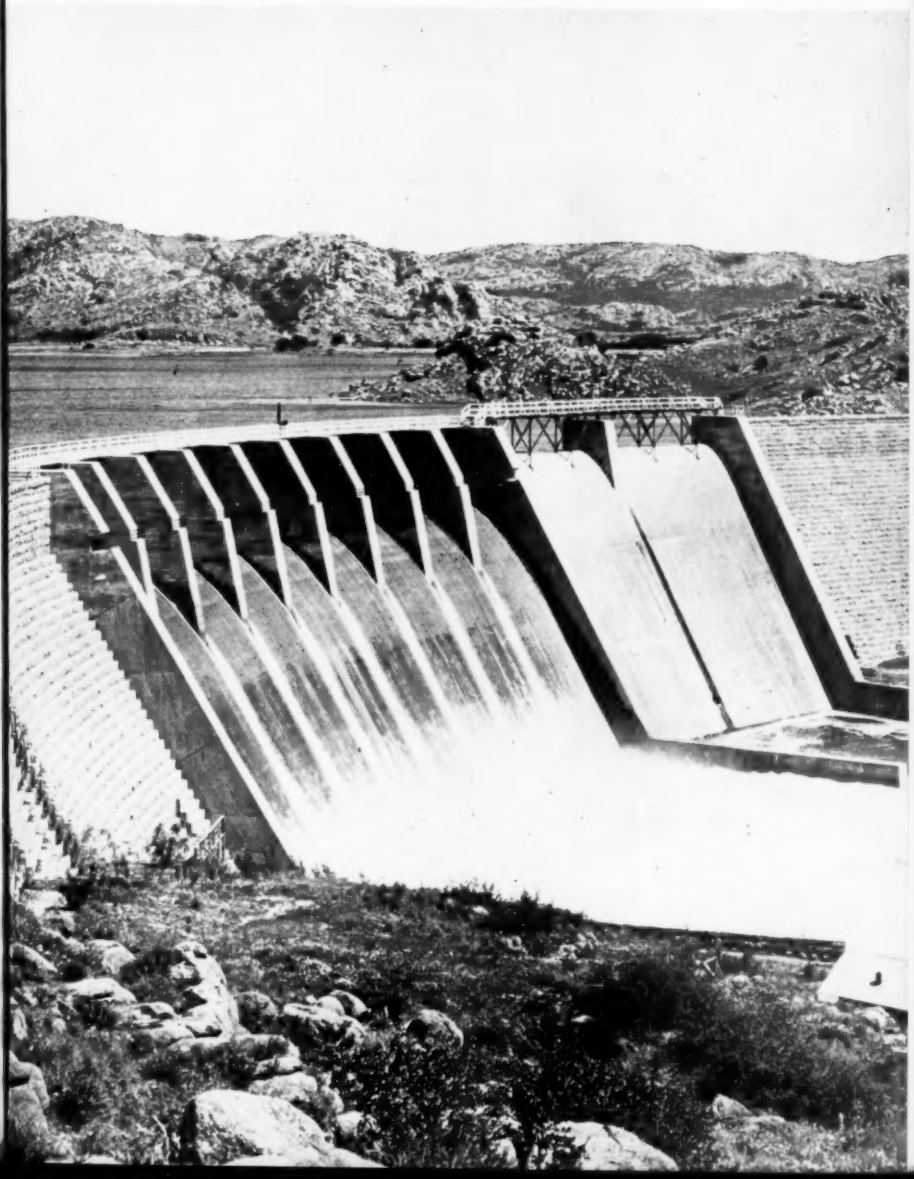
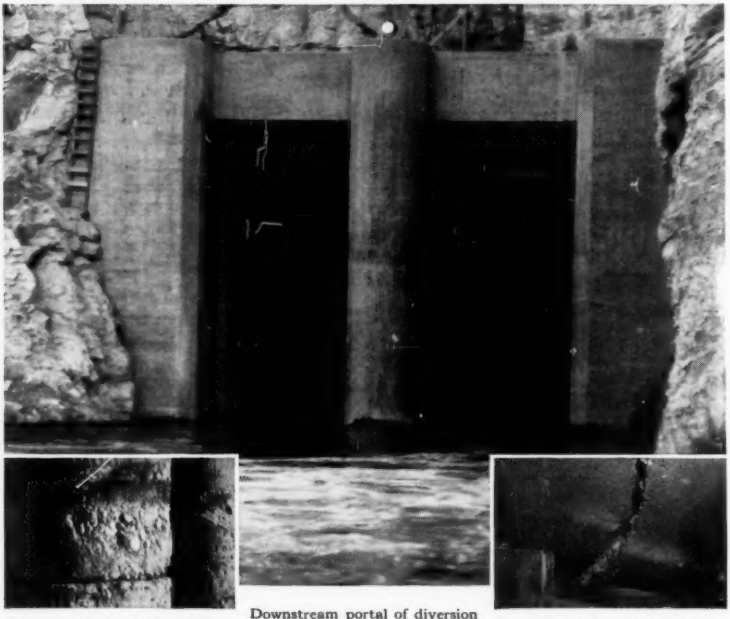
ACI News Letter

Vol. 21 No. 2 JOURNAL of the AMERICAN CONCRETE INSTITUTE October 1949



PREPAKT REPORTS ON...

MONOLITHIC CONSTRUCTION



Example of weathering failure at construction joints in a concrete pier.

Downstream portal of diversion tunnel. Monolithic construction was possible only through the use of Prepakt Concrete.

Example of shear failure along construction joint in a tunnel arch section.

Why tolerate unnecessary construction joints? Construction joints require preparation. Even when skillfully made, construction joints are the weakest part of a structure with respect to weathering, strength, and passage of unwanted water. Prepakt offers monolithic construction in addition to providing superior strength, low cement content, zero setting shrinkage, less drying shrinkage, and high weather resistance.

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ACI News Letter Contents

October 1949

On the Cover—Altus Dam, Okla., U. S. Bureau of Reclamation structure, has a masonry facing and no joints. The use of a portland-pozzolan cement using pumicite is described in "The Use of Portland-Pozzolan Cement by the Bureau of Reclamation," p. 89, this issue.

Courtesy
U. S. Bureau of Reclamation

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Program for Regional Meeting

Hotel Kenmore, Boston, Mass. November 10-11, 1949

THURSDAY, NOVEMBER 10

9:00 a.m. REGISTRATION STARTS

11:00 a.m.—12:30 p.m. GENERAL MEETING

Director PAUL W. NORTON, Chairman

Greetings

The Commonwealth of Massachusetts
PAUL E. DEVER, Governor

The City of Boston
JAMES M. CURLEY, Mayor

Engineering Schools
JAMES R. KILLIAN, President, Massachusetts Institute of Technology

Engineering Societies
CARROLL FARWELL, President, Engineering Societies of New England

Response

HERBERT J. GILKEY, President, American Concrete Institute

Address—"A Study in Concrete"

C. H. SCHOLER, Head, Department of Applied Mechanics, Kansas State College

12:30—2:00 p.m. INFORMAL LUNCHEON

Director H. L. KENNEDY, Chairman

Introduction of Directors of the American Concrete Institute

Brief talk by President of the American Concrete Institute

(Tickets obtained at time of registration. Students invited at nominal charge.)

2:00—5:00 p.m. FIRST TECHNICAL SESSION

Chairman—F. N. WEAVER, Professor of Civil Engineering, Tufts College

Design and Construction of a Circulating Water Intake for Venice No. 2 Power Plant
W. S. COLBY, Structural Engineer, Stone & Webster Engineering Corp.

Construction of Long Span Concrete Arch Hangar at Limestone Airforce Base
JOHN E. ALLEN, Chief of Engineering Division, U. S. Engineering Office, Boston District

Concreting on the Ottawa Valley Project of the Hydro-Electric Power Commission of Ontario
A. L. MALCOLM, Assistant Engineer, and R. B. YOUNG, Assistant Director of Research, Hydro-Electric Power Commission of Ontario, Toronto, Ont., Canada

Pozzolanic Materials and Their Use in Concrete
RAYMOND E. DAVIS, Director, Engineering Materials Laboratory, University of California, Berkeley

4:00—5:00 p.m. LADIES TEA

At one of Metropolitan Boston's noted locations. All ladies invited.

6:30—10:00 p.m. DINNER

Chairman—ALBERT HAERTLEIN, Professor of Civil Engineering, Harvard University

Address—"France Turns the Corner"
DONALD COPE McKAY, Professor of History, Harvard University

(Tickets for dinner to be obtained at time of registration.)

FRIDAY, NOVEMBER 11

9:30 a.m.—12:30 p.m. SECOND TECHNICAL SESSION

Chairman—W. C. VOSS, Professor of Building Construction, M.I.T.

Essential Properties of Pavement Concrete
FRANK H. JACKSON, Principal Engineer of Tests, Bureau of Public Roads

Precast Units for Short Span Bridges
ROBERT C. HANCKEL, Consulting Engineer

Armistice Day Observance
Remarks by General JAMES F. McMANMON, Commissioner of Airports

Precast Concrete Panel Type Multistoried Construction
THOMAS F. GILBANE, President, Gilbane Building Company

Research on Concrete Durability
HUBERT WOODS, Director of Research, Portland Cement Association, Chicago

Closing Remarks

E. S. GRAMSTORFF, Professor of Civil Engineering, Northeastern University

1:30—5:00 p.m. INSPECTION TRIPS

Arranged at time of registration with committee in charge.

The Boston Regional Meeting committee, co-chairmen Henry L. Kennedy and Paul W. Norton, consists of Miles N. Clair, sub-chairman in charge of program, L. C. Blake, Emil Gramstorff and Dean Peabody. The ACI Board of Direction and Technical Activities Committee will hold their regular fall meetings Wednesday, November 9, prior to the Regional Meeting which starts on Thursday.

1949 Nominating Committee Report:

President: Jackson
Vice-president: Goldbeck
Directors: Cummings, Tyler, Whitney, Wuerpel

The 1949 ACI Nominating Committee, consisting of Franklin R. McMillan, chairman, Robert F. Blanks, Roy W. Crum, Raymond E. Davis, Harrison F. Gonnerman, Frank E. Richart, Stanton Walker and Morton O. Withey, reports the following nominations:

For President

FRANK H. JACKSON to succeed Herbert J. Gilkey for a one-year term beginning at the February 1950 convention.

Mr. Jackson, Principal Engineer of Tests, Bureau of Public Roads, Washington, D.C., was elected vice-president in 1948. He has been an ACI Member since 1924 and is a member of ACI Committees 212, 609, 611, 613, and 617. Author or co-author of seven ACI papers in the past 20 years, he was awarded the Wason Medal for the most meritorious paper in 1948 with Harold Allen for "Concrete Pavements on the German Autobahnen." He is a member of the Technical Activities Committee, and was a member of the Advisory Committee as chairman of Dept. 900, Joint Efforts, 1929-46; member of Program Committee, 1938-40; Publications Committee member, 1941-46; member of the Board of Direction, 1937-38 and 1945-46; and Director-at-Large, 1946-47.

For Vice-president

A. T. GOLDBECK for 2-year term, beginning at the February 1950 convention.

Mr. Goldbeck, Engineering Director, National Crushed Stone Association, Washington, D. C., was elected a Director in Feb. 1948, and is a member of Committees 115, 325, 613, 617 and 621. He has been an ACI Member since 1926; a member of the Advisory Committee, 1922-23; and of the Publications Committee, 1944-46. He has had many contributions published in the ACI JOURNAL.

Directors

For directors, 3-year terms, four nominations for as many places on the Board: A. E. CUMMINGS, I. L. TYLER, CHARLES S. WHITNEY and C. E. WUERPEL.

Mr. Cummings, Director of Research, Raymond Concrete Pile Co., New York, N. Y., has been an ACI Member since 1924 and is chairman of Committee 323—Prestressed Reinforced Concrete.

Mr. Tyler, Manager Field Research, Portland Cement Assn., Chicago, Ill., is a member of the Technical Activities Committee. He has had several papers published in the ACI JOURNAL, is a member of ACI Committees 207, 609, 611, 613, 620 and is chairman of Committee 621—Aggregate Selection, Preparation Handling and Use. He has been an ACI Member since 1935.

Mr. Whitney, Ammann and Whitney, consulting engineers of New York and Milwaukee, was Wason Medalist for the most meritorious paper in 1932 for "Plain and Reinforced Concrete Arches," and has been an ACI Member since 1920. He was a member of the Board of Direction, 1945-46, and is chairman of Committee 312—Plain and Reinforced Concrete Arches, as well as a member of Committee 214.

Mr. Wuerpel, Technical Director, Marquette Cement Mfg. Co., Chicago, Ill., was awarded the Leonard C. Wason Medal for noteworthy research for the work reported in his 1946 paper "Laboratory Studies of Concrete Containing Air-Entraining Admixtures." He is a member of Committees 115, 214 and 604 and has been an ACI Member since 1937.

The 20 candidates for membership on the 1950 Nominating Committee—five to be elected — are:

J. F. BARBEE
STEPHEN J. CHAMBERLIN
MILES N. CLAIR
HERBERT K. COOK
HARMER E. DAVIS
PHIL M. FERGUSON
ALEXANDER FOSTER, JR.
A. S. JANSSEN
M. B. LAGAARD
G. L. LINDSAY
HARMON S. MEISSNER
NOLAN D. MITCHELL
H. C. ROSS
R. W. SPENCER
ERNEST O. SWEETSER
L. W. TELLER
A. G. TIMMS
C. A. WILLSON
KENNETH B. WOODS
PAUL M. WOODWORTH

☆ ☆ ☆

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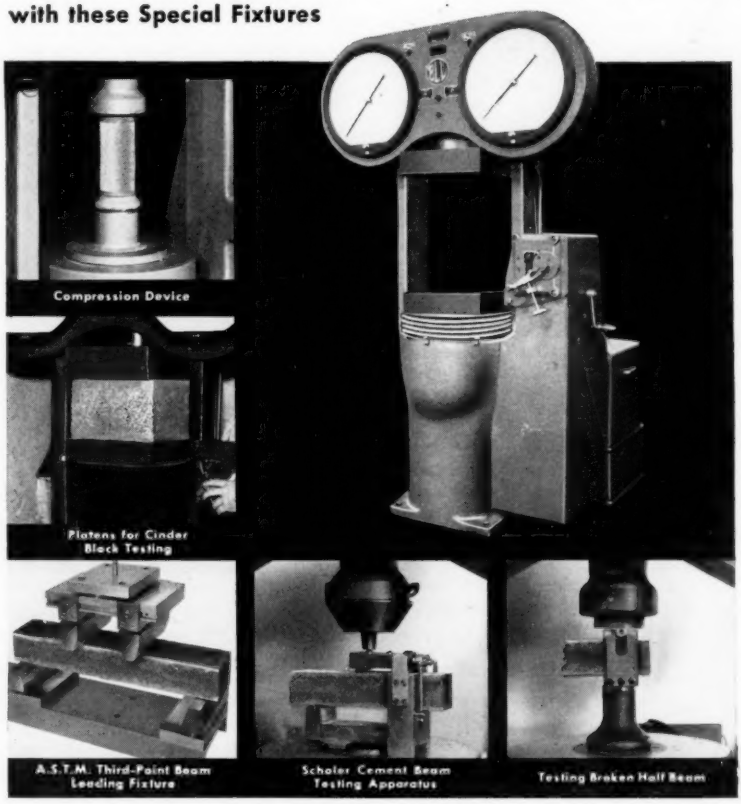
46th Annual Convention
in Chicago, Edgewater Beach Hotel

☆

February 20, 21, 22

new fields of use for the new BALDWIN Cement Testing Machine

with these Special Fixtures


Compression Device
Platens for Cinder Block Testing
A.S.T.M. Third-Point Beam Loading Fixture
Schaler Cement Beam Testing Apparatus
Testing Broken Half Beam

The broadened opportunities for cement and concrete testing opened by the new Baldwin 300,000 lb. machine are further expanded by available special fixtures.

These devices provide more detailed information, and facilitate the direct determination of such data as crushing strength, beam characteristics, and three-point loading reactions. Results provide valuable design factors which cannot always be inferred from straight compression tests.

The Baldwin 300,000 lb. testing machine meets all A.S.T.M. requirements, handles concrete cylinders 8" x 16" and building blocks up to 12" wide x 18" long. Write for details.

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The Baldwin Locomotive Works, Philadelphia 42, Pa., U. S. A. Offices: Birmingham, Boston, Chicago, Cleveland, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Seattle, St. Louis, Washington. In Canada: Peacock Bros., Ltd., Montreal, Quebec.

Who's Who This Month

Robert F. Blanks

Robert F. Blanks, Chief of the Research and Geology Division, U. S. Bureau of Reclamation, Denver, Colo., reports on "The Use of Portland-Pozzolan Cement by the Bureau of Reclamation," p. 89.

Mr. Blanks, a past president of ACI and presently a member of the Board of Direction, has served on many committees and has contributed frequently to the ACI JOURNAL. His most recent article was "Practices, Experiences and Tests with Air-Entraining Agents in Making Durable Concrete," in co-authorship with W. A. Cordon, in the February JOURNAL.

Mr. Blanks has been with the Bureau of Reclamation since 1925. He also is active on A.S.T.M. and A.S.C.E. committees.

Walter H. Price and George B. Wallace

For the past year Walter H. Price and George B. Wallace, Research and Geology Division, U. S. Bureau of Reclamation, have been evaluating the resistance of concrete and protective coatings to erosion, including studies of cavitation, high velocity water jet and abrasion erosion.

They describe a machine used for producing cavitation erosion in the laboratory in "Resistance of Concrete and Protective Coatings to Forces of Cavitation," p. 109.

Mr. Price, Head of Materials Laboratory, U. S. Bureau of Reclamation, Denver, Colo., has been with the Bureau since 1930; the past 15 years in materials testing and research related to the construction of large concrete structures. Prior experience includes structural design of Hoover Dam spillways and power plant and hydraulic model studies in connection with spillway designs. He is chairman of Committee 613 and Committee 210. Previous ACI papers are "Properties of Concrete Mixes," Apr. 1940, "Erosion of Concrete by Cavitation and Solids in Flowing Water," May 1947, and "Tests of Lightweight-Aggregate Concrete Designed for Monolithic Construction," Apr. 1949.

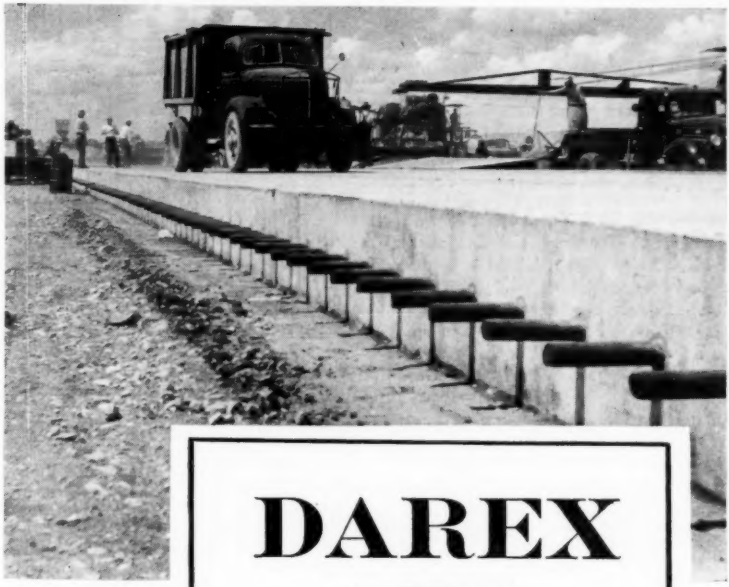
Mr. Wallace, Materials Engineer for the Bureau, has been with the research laboratories since 1945. Other studies performed by Mr. Wallace and published in Bureau reports are: investigation of the factors influencing mass and density measurements applicable to concrete work, investigation of the effects of delay between batching and mixing of moist aggregate and cement, bonding of prepacked concrete to hardened mixed concrete, investigation of mortars for use in low cost canal lining, and training engineers and engineering aids from field projects in the principles of concrete mix design and control.

Prior to joining the Bureau staff, Mr. Wallace served five years in the Army Air Force, including combat service in the South Pacific and research work with the Air Force Department of Research and Development. He received his B. S. and M. S. in civil engineering from the University of Colorado.

K. P. Billner and Bert M. Thorud

K. P. Billner and Bert M. Thorud, co-authors of "Vacuum Processes Applied to Precast Concrete Houses," p. 121, are well acquainted with vacuum processes used in concrete construction. Mr. Billner is President of Vacuum Concrete, Inc., Philadelphia, Pa. and Mr. Thorud, architect and structural engineer of Phoenix, Ariz., is also a consulting engineer for the same firm.

Mr. Billner developed the lightweight concrete "aerocrete," which was first used in the Imperial British Exposition of 1925. He invented vacuum concrete in 1935 and also invented a process of



Patterson Field, Ohio. 21-in. concrete runway. 25-in. taxiway. Darex AEA used throughout. Courtesy U. S. Corps of Engineers.

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The proven air entraining agent for concrete. Darex AEA is being used in all types of concrete work throughout the world.

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Distributor warehouse stocks conveniently available throughout North and South America and in most foreign countries.

rock excavation by artificial freezing, and electric prestressing of reinforcing steel described in his ACI JOURNAL contribution for June, 1943.

He is a director of the Aerocrete Corp. of America and organized similar concerns in Canada and England. He has been active in engineering and building construction in both Sweden and the United States. He served as an irrigation engineer on the West coast and locating engineer for the Northern Pacific Railroad and the Washington State Highway Dept. As a bridge engineer on the Columbia River Highway, he designed and supervised the construction of the first concrete bridges in Oregon. He graduated from Chalmers Technical Univ., Sweden, in 1906 with a degree in civil engineering.

Mr. Thorud was previously Chief Structural Designer for M. H. McCloskey Shipbuilding Co., who built reinforced concrete cargo ships during World War II. He was the Senior Engineer in charge of material research for the Federal Public Housing Authority, Chief Structural Engineer for A Century of Progress Centennial World's Fair, Chicago, and Design Engineer for Holabird and Root, Architects, Chicago.

He graduated from the University of Illinois in 1918 with a B.S. in architectural engineering.

James M. Polatty

"New Type of Consistency Meter Tested at Allatoona Dam", p. 129, by James M. Polatty, describes a meter used to determine the consistency of a mix while in the mixer drum.

Mr. Polatty as Materials Engineer, Corps of Engineers, Mobile District, Allatoona Dam, has been in charge of design and control of concrete mixes, materials, plant, equipment and laboratory work since 1948. He has also served with the field engineer in directing concrete placing procedures and construction. Mr. Polatty was with the U. S. Navy Civil Engineer Corps, 1945-48, and prior to that was Head of Mobile District Laboratory, Corps of Engineers, Mobile, Ala., 1941-45.

He was associated with the Harza Engineering Co. on the Santee Cooper River Project, 1939-41, and the South Carolina Highway Dept. Testing Laboratory after graduation from the University of South Carolina in 1937 with a B.S. in civil engineering. Mr. Polatty is also a licensed professional engineer in Georgia and a member of A.S.C.E.

F. L. Fitzpatrick and W. Serkin

F. L. Fitzpatrick, General Manager, and W. Serkin, Chief Chemist, Rocla Ltd., Melbourne, Australia, report the "Effect of Mixing Sequence on the Properties of Concrete," p. 137.

Mr. Fitzpatrick joined Rocla Ltd. in 1922, was Works Manager of the Melbourne plant, 1924-29, and was appointed General Manager in 1929. He is the inventor of the rubber joint used on the company's pressure pipes, the Rocla prestressed pipe making process, and other pipe manufacturing techniques patented in Australia and abroad.

Mr. Serkin graduated from the Technical University of Vienna, serving as Research Director, Rhenish Trass Producers Assn., Germany, before joining Rocla Ltd. in 1939. He is in charge of chemical research and production of chemical compounds used in admixtures and anti-corrosion work.

Rocla Ltd. manufactures reinforced concrete pipe and has eight plants in various parts of Australia.

Found—Reviewers

In response to a request in the September News Letter for readers to review Dutch periodicals, J.W.T. van Erp and Charles C. Zollman have volunteered.

Mr. van Erp, designer with the George A. Fuller Co., New York, is a graduate professional engineer of the University of Delft, Netherlands. Mr. Zollman, staff engineer, Preload Corp., New York, studied under Prof. Gustave Magnel, Belgium, and is familiar with European concrete practices and has translated Prof. Magnel's book *Le Beton Precontrait* into English.

This Improved Bar Reduces Objectionable Cracks in Reinforced Concrete

Tests have demonstrated the effectiveness of high bond strength, as provided by the new improved Bethlehem Reinforcing Bar, in controlling the formation of cracks in reinforced concrete.

The alternately-sloped, closely-spaced lugs on the improved Bethlehem Reinforcing Bar transfer stress from steel to concrete much more effectively than older bars with smaller, more-widely-spaced lugs. The higher bonding strength obtained means low slips at working loads, resulting in the formation of small closely-spaced cracks in the concrete, rather than the wide unsightly cracks frequently experienced.

The improved Bethlehem Reinforcing Bar meets every requirement of the new ASTM Specification A305, defining minimum requirements for reinforcing bar deformations. It is made from new-billet steel, and comes in all sizes from ⅜ in. to 1¼ in. For additional information, get in touch with the nearest Bethlehem sales office.

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BETHLEHEM, PA.

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Export Distributor: Bethlehem Steel Export Corporation

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BETHLEHEM
Reinforcing Bars

New Members

Of the 31 applications approved for membership for the month of August there were 20 Individual, 7 Junior and 4 Student.

New York was top membership state for the month with 4 new member applicants. Cuba and England shared honors for second place with 3 each. The membership total September 1 became 4767.

California

Bennetsen, Earl M., (Indiv.) 439 Sequoia Dr., Pasadena, Calif.

District of Columbia

Gurewitz, Milton A., (Indiv.) 7019 Georgia Ave. N. W., Washington 12, D. C.

Idaho

Green, Clarence R., (Indiv.) Box 13, Inkom, Idaho

Illinois

Chastain, Homer L., (Indiv.) 250½ N. Park St., Decatur, Ill.

Jones, Robert L., (St.) 822 Buena, Chicago 13, Ill.

Indiana

Hagedorn, James H., (St.) 276 Dillon Hall, Notre Dame, Ind.

Kansas

Henderson, Jurdon R., (Indiv.) Consolidated Cement Corp., Fredonia, Kan.

Michigan

Legatski, Leo M., (Indiv.) 301 W. Engineering Bldg., University of Michigan, Ann Arbor, Mich.

New Jersey

Gonzales, R., (Indiv.) 33 Branch Brook Dr., Belleville, N. J.

New York

Fisher, Gordon P., (Jr.) School of Civil Engineering, Cornell University, Ithaca, N. Y.

Hodes, Emanuel B., (Indiv.) 18 W. 71st St., New York 23, N. Y.

Mains, Robert M., (Indiv.) School of Civil Engineering, Cornell University, Ithaca, N. Y.

Oberly, E. B., (Indiv.) 45 Tudor City Place, Apt. 1108, New York 17, N. Y.

North Carolina

Brockway, George L., Jr., (Jr.) 10 Sunrise Lane, Havelock, N. C.

Oregon

James, Arthur M., (Indiv.) 208 Southwest Stark St., Portland 4, Ore.

South Carolina

Tewkesbury, Alan M., III, (Jr.) Fauberg St., Aiken, S. C.

Virginia

Moore, C. Dickson, Jr., (Jr.) 702 Redgate Ave., Norfolk, Va.

Washington

Berry, Curtis C., (Indiv.) Box 255, Coulee Dam, Wash.

Wisconsin

Fluck, Paul G., (Indiv.) Education & Engineering Bldg., University of Wisconsin, Madison 6, Wis.

Australia

Denniss, Ian W., (Indiv.) Staff House, Hydro Electric Commission, Butler's Gorge, Tasmania, Australia

Canada

Pierce, Mervin Booth, (Jr.) Saskatchewan Landing, Saskatchewan, Canada

Continued on p. 22

We Want to Know—

ACI Members will recall that the membership classification forms circulated last year contained a question—"What suggestions have you for the Technical Activities Committee as to papers or reports you'd like to see published; subjects you'd like to see discussed?" This is the second group of such questions published, the first group appearing in the September *News Letter*.

One thing that will undoubtedly develop from the many replies is a special session at the Institute's convention next February at which a panel of "experts" would head the discussion.

Meanwhile the ACI JOURNAL will publish anonymously a good many of these questions and suggestions. JOURNAL publication is intended to bring responses which may be the answer or partial answer to questions asked. Readers are not only invited to answer those questions appearing in print, but to send other suggestions and queries as well. Some of these questions have been answered in past ACI literature and will be covered more thoroughly in future issues of the JOURNAL Letters from Readers sections.

—Editor

Salt water

Can salt water be used effectively for mixing concrete?

Insulating concrete

Why don't you form a committee for the investigation of insulating concretes? These concretes are being used more and more.

Special anchorage and column dowels

I would like to see special anchorage discussed and definitely tied down as to bar lengths, etc., also the matter of column dowels from column to footing. Under the present code, a column with large size bars and a shallow footing requires an excessive number of small size bars as dowels. I do not agree with paragraph 1206 of the ACI Building Code. My practice is to use the same size and number of dowels as vertical bars in the column. Advantage should be taken of the bearing value of concrete in carrying additional load and lessen the load carried by the dowels thus requiring less bond area for the dowels embedded in the footing.

Marine structures

I am interested in the application of concrete to marine structures and harbor works. More articles on the effect of sea water, such as the Terzaghi paper in the June 1948, JOURNAL would be of great interest.

Concrete barges

Operating records of concrete barges, along with further discussion of peacetime concrete barge construction, would be interesting.

High bond bars

Since the WPB permitted using f_s = 24,000 psi without increasing the allowable bond stress, we have heard much about the relative merits of various types of reinforcing bars in respect to bond. The new high bond bars have reduced effective area. I should like to see an investigation of the cost (in reduced area for resisting tensile stress) of the increased resistance to failure in bond of the new bars.

Stresses in slabs

Have there been any investigations on the stresses in slabs supported on three sides and fixed on three sides; and slabs supported or fixed at a long side and supported by columns at the two outside corners or along the two short sides by walls? Timoshenko in his *Strength of*

Materials—Advanced Theory summarizes the results of tests on thin steel plates under some of the above conditions. However, his tests were on a homogeneous and isotropic material and it would take a good deal of imagination to consider reinforced concrete in that category.

Membrane method for curing concrete pavement

I would like to see a paper on the work done by the Michigan State Highway Dept. on an appraisal of the membrane method of curing concrete pavement.

Better concrete with longer life

The ACI JOURNAL should concentrate on papers stressing the importance of aggregate quality and gradation, the mix proportions, water control and the proper placing and curing of concrete. In a large percentage of small jobs and in many large jobs, only half the potential life and service of concrete is obtained due to sloppy control and poor workmanship. In many cases, the proper "know-how" and control would double the life and quality of the concrete. The American concrete industry could well acquire some of the European care and skill in mixing and placing concrete.

Pozzolans and alkali-aggregate reaction

What is being done to develop a pozzolan that will definitely stop alkali-aggregate reaction? [See "The Use of Portland-Pozzolan Cement by the Bureau of Reclamation," by Robert F. Blanks, p. 89, this issue—Editor.]

Pointing compounds

What are suitable pointing compounds, either mortar or plastic material?

Lignite

Concrete sands from the Missouri River and Mississippi River contain a small percent of lignite, which under certain conditions of placing concrete floors, etc., pops out causing surface blemishes. What is a method of reducing lignite content to less than 0.01 percent?

The future

I realize most of the JOURNAL papers are about the technical nature of concrete, cement, aggregates, etc., but wonder if any others, besides myself, would be interested in papers discussing the future of concrete and concrete products usage as compared to steel and wood construction. Topics concerning the economics, future markets, trends in different areas and the advantages of concrete as compared to other materials should be of interest.

Clinker equilibrium

In calculating portland cement compound composition it is assumed that the clinker attained a state of equilibrium. Is this correct for all cements? What evidence is there of this?

Dry mix concrete

I feel that the ACI JOURNAL has completely neglected the field of "dry mix concrete" studies.

Sidewalks

Concrete sidewalks is a long neglected subject. The existing references are meager, consisting mostly of a few paragraphs in highway engineering handbooks. It deserves a paper in the JOURNAL.

Water treatment structures

What can be done to prevent deterioration of concrete construction and basins subjected to chemicals used in water treatment works?

Everyday problems

I would like to see more articles of everyday practical value to men who are actively engaged in construction design.

C. C. Merrill

C. C. Merrill, vice-president and general manager of the Southwestern Portland Cement Co., Los Angeles, Calif., died recently at his home in Beverly Hills. His death occurred within a month of the death of Frank H. Powell, president of the company. Born in Alton, Ill., Mr. Merrill went to Los Angeles in 1893. He became associated with Carl Leonhardt who was then in the contracting business and later founded the cement company, and became vice-president of the firm in 1907. Both Merrill and Powell were ACI Members, representing Southwestern Portland Cement Co.

Honor Roll

February 1, 1949 to August 31, 1949

There is little change in the order of our active member-getters for the period ending August 31, 1949. The Morgan family maintains its hold on the two top spots on the Honor Roll.

The 293 names listed below represent 6 percent of our total membership. We'd like to see the remaining 94 percent swing into action and help us reach our membership goal of 5000 Members by January 1, 1950.

Newlin D. Morgan	42½
Newlin D. Morgan, Jr.	26
F. N. Menefee	11½
R. H. Sherlock	7
Jaime Alberto Mitrani	6
Jose Antonio Vila	5
H. J. Gilkey	4
J. Vicente Orozco	4
Frank E. Richart	3½
Thomas E. Stanton	3½
Raymond E. Davis	3
John J. Hogan	3
H. D. Jolley	3
Barton Jones	3
J. W. Kelly	3
James A. McCarthy	3
William T. Neelands	3
Leon Venegas	3
Stanton Walker	3
R. A. Caughey	2½
Roger H. Corbetta	2½
A. J. McElrath	2½
Paul W. Abeles	2
J. F. Baxter	2
W. S. Cottingham	2
John G. Dempsey	2
Ambrosio R. Flores	2
Zorislav Franjetic	2
H. F. Gonnerman	2
Henry E. Griset	2
V. P. Jensen	2
Emory E. Johnson	2
R. R. Kaufman	2
Karl W. Lemcke	2
Frederic L. Mavis	2
William S. Moore	2
William D. Nowlin	2
Luis Pardes-Manrique	2
Luis A. Pietri-Lavie	2
Dan H. Pletta	2
G. E. Troxell	2
George Winter	2
Roberto Barillas F.	1½
Harold S. Carter	1½
S. J. Chamberlin	1½
H. C. Delzell	1½
Adly W. Gindy	1½
Adli Milik Hanna	1½
Elmo C. Higginson	1½
Robert L. Mauchel	1½
Sam McCluer	1½
Carl A. Menzel	1½
Edward W. Scripture, Jr.	1½
Roy T. Sessums	1½
Thomas C. Shedd	1½
Calvin T. Watts	1½
Frank W. Wheeler	1½
Jerome O. Ackerman	1
A. Amirikian	1
William F. Anderson	1
Samuel Baker	1
J. A. Bakker	1
Charles F. Ball	1
John H. Bateman	1
Donald C. Beam	1
Oscar Benedetti	1
H. J. Bezette	1
Robert F. Blanks	1
Hans H. Bleich	1
Ernest M. Bowles	1
R. W. Brandley	1
Carlos Mora Bravo	1
Milton Brumer	1
Sterling Lowe Bugg	1
R. Y. Bush	1
Adraino Carbone	1
R. V. Chate	1
H. Clare, Jr.	1
E. F. J. Clark	1
H. W. Comack	1
R. E. Copeland	1
Alirio Cornejo	1
Hendrik Cornelissen	1
G. H. C. Crampton	1
Jacob J. Creskoff	1
Ray A. Crysler	1
Jose A. Cuevas	1
Harmer E. Davis	1
Peter J. Doanides	1
A. T. Docal	1
A. H. Douglas	1
W. H. Droege	1
C. Martin Duke	1
Belmon U. Duvall	1
Harlan H. Edwards	1
J. M. Faircloth	1
Ewell W. Finley	1
F. L. Fitzpatrick	1
George W. Ford	1
Robert W. Freeman	1

Carmelo Galindez 1
Gerald K. Gillan 1
Castor Segunda Goa 1
Ali N. Gokyigit 1
E. Gonzalez-Rubio 1
Armour T. Granger 1
Samuel J. Green 1
K. Hajnal-Konyi 1
Robert J. Hansen 1
Bernard C. Herring 1
M. D. Hicklin 1
Percy Howat 1
Franklin D. Howe 1
Myron A. Howe 1
J. W. Hubler 1
Alberto Dovali Jaime 1
J. P. Jain 1
V. P. Jensen 1
R. C. Johnson 1
Milton Kellert 1
Edgar R. Kendall 1
K. V. Kini 1
Ralph W. Kluge 1
Max Krueger 1
Blas A. Lamberti 1
George E. Large 1
William Lerch 1
Leslie D. Long 1
Winthrop E. Luke 1
Charles Macklin 1
Glenway Maxon 1
H. J. McGillivray 1
George C. McLeod 1
F. R. McMillan 1
M. J. McMillan 1
Jesus Mesa 1
Robert B. B. Moorman 1
Robert Morris 1
R. F. Moss 1
George G. Nichols 1
LeRoy T. Oehler 1
Czeslaw Ozieblowski 1
Orin G. Patch 1
Jose F. Perez 1
Anthony F. Pessolano 1
Charles Peterson 1
A. Edward Piller 1
James M. Polatty 1
W. S. Powell 1
Emil Praeger 1
Raul Miguel Rivero 1
Albert Rootberg 1
John A. Ruhling 1
Emil Schmid 1
Saul Shaw 1
Isaac S. Shina 1
Ranbir Singh Shrikant 1
Richard Skalak 1
William Furber Smith 1
Luis G. Solano A. 1
Frederick E. Springate 1
Alois Starkmann 1
W. B. Summer 1
Manabu Tanaka 1
Maurice Taylor 1
T. W. Thomas 1
I. L. Tyler 1
Oscar J. Vago 1
Joseph J. Waddell 1
Bertrand H. Wait 1
John M. Wells 1
J. G. Welsh 1
Donald K. Woodin 1

The following credits are, in each instance "50-50" with another member.

Birger Arneberg
Michel Bakhoum
C. Harold Barcus
Charles H. Barker
Hugh Barnes
Frank Baron
J. F. Barton
J. E. Bates
Aaron H. Bauman
E. W. Bauman
H. W. Beckingham
A. H. Brewer
Harold W. Brewer
A. R. Brickler
Robert G. Burnett
J. A. Carrick
Napoleon V. Campomanes
W. R. Chandler
Arthur P. Clark
Leo Coff
T. F. Collier
R. D. Conrow
W. A. Coolidge
Leo H. Corning
Dwight A. Covington
Lauro M. Cruz
A. E. Cummings
M. H. Cutler
W. A. Davis
Curzon Dobell
Ernest A. Dockstader
W. J. Emmons
J. L. Faisant
A. V. Farley
Phil M. Ferguson
Benjamin Forsyth
J. E. Guest
A. W. Haddow
J. R. G. Hanlon
W. S. Hanna
M. J. Hawkins
A. E. Hiscox
S. C. Hollister
Albert C. Hooke
S. E. Hyde, Jr.
Melvin Fu Hoon Ja
Bruce Jameyson
Bruce M. Johnson
Samuel Judd
Frank Kerekes
Lane Knight
Carl A Koerner
James V. Mandia
Henri Marcus
Hudson Matlock
J. W. McBurney
Robert B. McCalley, Jr.
T. R. McCullough
Harmon S. Meissner
Jack Robert Miller
Sylvester Morabito
Wm. Morris
S. Neatwait
Philip M. Noble
Calvin C. Oleson
George L. Otterson
Chester B. Palmer
Douglas E. Parsons
Robert J. Perrich
George Nelson Perry
Alan H. Pilling
Warren Raeder
Irvin S. Rasmusson
F. V. Reagel
Francisco M. Rexach
William H. Rowan
Fred H. Ryan
Cecil F. Schaaf
Jack S. Short
Ruben Ruiz Silva
Tirlochan Singh
Myron M. Smith
Charles A. Snyder
H. F. Sommerschield
G. W. Stokes
E. Q. Sullivan
E. O. Sweetser
S. Szczerbaniewicz
Anton Tedesko
William H. Thoman
J. Trueman Thompson
E. W. Thorson
LeRoy A. Thorssen
Homer Thrall
Fehiman Tokluoglu
Gregory Tschebatarioff
John Tucker, Jr.
Maxwell Upson
F. E. Votaw
Norman Wagner
W. Wayne Wallace
M. H. Walters
George W. Washa
David Watstein
J. C. Watt
W. R. Waugh
Carl Weber
J. Wegrowski
Charles S. Whitney
H. F. Williams
Paul C. Winters
M. O. Withey
Thomas Worcester
K. W. Wright
Charles E. Wuerpel
Alexander H. Yeates
R. B. Young
Robert Zaborowski

Are YOU
"MEMBER CONSCIOUS"
? ? ?

Positions and Projects — ACI Members

Committee 315

Henry L. Neve, U. S. Bureau of Reclamation, Denver, Colo., has been appointed to ACI Committee 315, Detailing Reinforced Concrete Structures, Raymond C. Reese, chairman. Mr. Neve is Head of the Design Unit, South Platte River Section and a member of ACI since 1944.

Committee 207 reorganized

Committee 207, Properties of Mass Concrete, has been reorganized under the chairmanship of Robert F. Blanks, U. S. Bureau of Reclamation, Denver, Colo. The following men were appointed to the committee and have accepted assignment: Federico Barona de la O, Nueva Santa Maria, Mexico D.F.; Raymond E. Davis, University of California, Berkeley, Calif.; Jerome M. Raphael, Bureau of Reclamation, Denver, Colo.; I. L. Tyler, Portland Cement Association, Chicago, Ill.; William R. Waugh, Office, Chief of Engineers, Washington, D.C.; and Roderick B. Young, Hydro-Electric Power Commission of Ontario, Toronto, Ont., Canada.

Originally designated Committee 108, Heat Developed in Concrete, in 1930, the committee was reorganized under the present title about 1940.

Germundsson and Freyssinet join Committee 323

Committee 323 — Prestressed Reinforced Concrete, has recently added Thor Germundsson and Eugene Freyssinet to its membership.

Mr. Germundsson is a structural engineer with the Portland Cement Assn., Chicago, Ill. Mr. Freyssinet is the ACI representative of the Societe pour l'Utilisation de la Precontrainte, Paris, France, and has done extensive work in Europe with prestressed construction. The Societe became an Institute member in June.

Walnut Lane bridge test

The Preload Corporation, Member of ACI, will test to failure a 160-ft prestressed concrete girder similar to those being used in the main span of the Walnut Lane Bridge, Philadelphia—which it is claimed will be the first prestressed concrete girder bridge in the United States. The testing of the girder, which will require approximately two days, will be conducted at the site under the supervision of Prof. Gustave Magnel of Ghent, Belgium. It is hoped that Professor Magnel, who is also a member of ACI, will make an informal address and read a paper on prestressed concrete structures. ACI members interested in witnessing the test and attending Professor Magnel's address should immediately contact the Preload Corporation, 211 E. 37th Street, New York 16, N. Y. for details and credentials to permit them to enter the test area. Exact date has not been set—it is expected to be during the week of Oct. 17.

Talents involved in Bureau of Reclamation construction

The diversified talents needed in large construction projects is emphasized by a list of the personnel necessary for the Colorado-Big Thompson project by the U. S. Bureau of Reclamation.

The divisions include engineering, planning, finance, operation and administration and the talents needed in each phase are:

Engineering — Civil — dams, canals, tunnels and structures; electrical—power plants, transmission lines; mechanical—water control gates, valves; surveying—location and construction, cadastral, area control and topographic feature details.

Planning — Economists — economic feasibility; hydrologists—water supply and utilization; hydraulic engineering—power machinery; irrigation specialists—water requirements; land aquisition.

Finance—Budget control; appropriation limitation; contract payments; wages and salaries (accountants, bookkeepers, stenographers, clerks).

Operation—Operation and maintenance; power sales and marketing; relations with consumers.

Continued on p. 18

PROFESSIONAL CARD

L. COFF, Consulting Engineer
198 Broadway, New York 7, N. Y.

PRESTRESSED CONCRETE STRUCTURES
Design, Estimates,
Construction Methods, Supervision

Continued from p. 17

Administration—Personnel; public relations; advertising and publicity; appropriations from Congress; long range planning; and legal problems (inter and intra state compacts and agreements).

ACI visitor

Huib Sprangers, civil engineer, Holland, was a visitor at ACI headquarters August 29. He is visiting the United States before joining his father's firm, one of the larger designing and contracting organizations in Holland, and is interested in the advanced phases of structural design and erection in this country.

N.S.G.A. and N.R.M.C.A. short course

The National Sand and Gravel Assn. and the National Ready Mixed Concrete Assn. have announced plans for their fourth annual Short Course of Instruction for Industry Technicians at the Univ. of Maryland, November 14 to 19.

Each November, for the past three years, the N.S.G.A. and N.R.M.C.A., in cooperation with the University of Maryland, have presented a week of classroom instruction for technicians in the sand and gravel and ready-mixed concrete industries. The course includes: basic factors affecting quality of concrete mixtures; air-entraining concrete; fundamentals of design of concrete mixes; laboratory demonstrations and discussions of tests for concrete and aggregates; aggregate specification problems and bituminous mixtures.

Howell appointed resident engineer

Lt. Col. H. K. Howell has been appointed to the Rock Island, Ill., district, Corps of Engineers, to be resident engineer of the Coralville flood control project on the Iowa River near Iowa City, Ia.

Danish National Institute of Building Research

The Danish National Institute of Building Research, Copenhagen, Denmark, recently issued its First Annual Report. The institute was established in March, 1947 and the report describes the circumstances that justified the establishment of the institute and outlines the plans and problems that occupied the first year.

The task of the institute is to follow, promote and coordinate technical, economic and other research work which may contribute to an improvement and reduction of building costs.

First year problems included work on remedying seasonal hindrances to housing construction, especially winter earthwork and concreting; heat insulation of walls, floors and roofs; investigation of floor cost, insulating capacities, etc.; emission of heat from the human body through convection and radiation; acoustic properties of gymnasia; and houses built of rammed earth.

In addition, research has commenced on a survey of ordinary building methods, standardization of building elements, prefabricated houses, farm housing and building documentation.

Investigations planned by the institute include designing of windows, load assumptions for floors and the future demand for housing.

Tuttle elected vice-president of Turner Construction Company

Edward X. Tuttle, New York City, has been elected by the directors of the Turner Construction Co., to the position of vice president in charge of new business for the company. Mr. Tuttle succeeds

SIKA for MAINTENANCE

Sika's products and methods for maintenance are economical and reliable. Sika seals leaks against pressure — durably seals joints against movement — repairs and protects concrete by patching or coating — for below or above grade work, for guniting or pressure grouting. Sika repairs and prevents damage to structures under all, even the most adverse conditions.

Send for our recommendations on problems of new construction and maintenance.

Check our catalog in Sweets Architectural and Engineering File.

SIKA CHEMICAL CORPORATION
PASSAIC, N. J.

Sika

J. P. H. Perry, who continues as vice-president and consultant on new business.

Since graduating from the Univ. of Michigan in 1930, Mr. Tuttle has been with Giffels and Vallet, Inc., for the past 10 years and during World War II directed important construction work at the Naval Operating Base, Norfolk, Va.

Mr. Tuttle's headquarters will be in Turner's New York office, but he will also have general supervision of contract negotiations in the company's other offices in Boston, Philadelphia and Chicago.

Breen elected president

J. M. Breen, executive vice-president and general manager of Canada Cement Co., Ltd., Montreal, Canada, has been elected president of the company. Mr. Breen joined the company in 1922 as technical engineer. He was appointed chief of technical staff in 1934, assistant general manager in 1947, and executive vice-president and general manager 1948, serving also as company representative in ACI.

Theodore O. Reyhner

Prof. Theodore O. Reyhner has been made an Associate Professor of Civil Engineering at the University of Denver, Denver, Colo., where he will teach structural engineering subjects. He was formerly an Associate Professor at the School of Architecture and Allied Arts of the University of Oregon.

H. P. Bigler

H. P. Bigler, Executive Vice-President of Connors Steel Co., Birmingham, Ala., has been made a member of the Industrial Relations Committee, National Assn. of Manufacturers. He is a member of the ACI Board of Direction.

Insley wins A.C.S. award

Herbert Insley, Chief of the Mineral Products Division, National Bureau of Standards, and F. P. Hall, Assistant Director of Research, Onondaga Pottery Co., were presented with the Ross Coffin Purdy Award of the American Ceramic Society at the society's annual convention in Cincinnati. The first to be so honored, Drs. Insley and Hall were cited for their outstanding contribution to ceramic literature. They are the authors of the book *Phase Diagrams for Ceramists*. Dr. Insley has also had several papers published in the ACI JOURNAL.

George E. Warren

George E. Warren has been elected to succeed the late Frank H. Powell as President of the Southwestern Portland Cement Co. Mr. Warren, who was company vice-president, has been active in the work of A.S.T.M. and the Portland Cement Assn., and is a member of ACI. He was with the Osborn, Ohio, plant of Southwestern Portland for many years.

NEW!

Heating Unit for Winter Jobs

- Ideal for Concrete Work
- Quickly Thaws out Materials
- Over One Million B.T.U. Output

Behlen **HEAT BLOWER**

$407 FOB-Columbus, Nebr.

A sturdy, dependable heating plant. Has many construction uses. Recommended for concrete work in low temperatures. Warms aggregate at batching plant; prevents freezing concrete while setting. Just the thing for drying and curing plaster or paint and other such jobs. Preheats machinery. Burns 1 to 9 gals. distillate or kerosene an hour; furnishes up to 1,100,000 B.T.U.'s direct heat per hour.

In Use on Federal and Private Construction

Built-in fan delivers up to 7000 CFM at ½ inch water pressure or 5000 CFM at 5 inches pressure up to 250°F output. Gasoline or electric motor furnished if desired. Adjustable outlet pipe is removable for adapting to fit job. Mounted on skids. Used on Federal and private construction. Almost 3,000 in use on farms dehydrating corn. Beat cold weather delays . . . write, wire for full information . . .

Behlen Manufacturing Co.

Dept. 7 Columbus, Nebr.

Tools, Materials, Services

Under this heading note will be made from time to time of producer literature of presumed technical interest (and available from its source for the asking) to ACI users of tools, equipment, materials, accessories and special services.

Strain gages

A 4-page bulletin illustrates the wide variety of uses that have been made of SR-4 bonded resistance wire strain gages. The numerous types of gages now available for determining the stresses and strains in structures and parts, in service or when subjected to stresses in the laboratory, are also described and illustrated. Copies of Bulletin No. 279 are available from The Baldwin Locomotive Works, Testing Equipment Dept., Philadelphia 42, Pa.

Mixer efficiency tested

The Danish National Institute of Building Research in collaboration with the Danish Testing Institute has begun a program of testing Danish concrete mixers. The investigation of 11 different mixers will include consumption when idling and working, mixing time and efficiency in emptying.

A limited supply of mimeographed copies of the outline of the testing program are available from ACI headquarters for the asking.

Changes in paver

A four page folder published by Chain Belt Co. describes two new design advancements now featured as standard equipment on Rex Pavers. The new hydraulic bucket is said by the company to provide positive control of spreading. The same lever that controls bucket travel, controls the opening of the bucket. The opening action of the pivoted gate can be stopped at any desired point. The redesigned boom can be elevated to provide a 10-ft bucket clearance at the end of the boom. This 10-ft elevation is said to give the maximum needed clearance without undue strain on the paver mechanism. The boom elevation is controlled by the same lever that operates the boom swing.

For a copy of Bulletin No. 49-17 write Chain Belt Co., 1600 West Bruce Street, Milwaukee 4, Wis.

Aerocrete construction

An 8-page booklet, "Lightweight Concrete Construction," published by the Aerocrete Construction Co., Ltd., Montreal East, Quebec, Canada, presents tables and drawings of various lightweight construction utilizing Aerocrete. The booklet includes precast roofs (flat and sloping), channel type precast slabs, precast floors, concrete joists, and various other uses of Aerocrete concrete.

Further information can be obtained from

340-Ft. SPAN U. S. AIR FORCE HANGAR
BUILT UNDER SUPERVISION OF THE CORPS OF ENGINEERS
SIMILAR HANGARS UNDER CONSTRUCTION FOR ARGENTINE GOVERNMENT

ROBERTS AND SCHAEFER COMPANY
ENGINEERS — CONSULTANTS
130 N. WELLS STREET, CHICAGO 6
NEW YORK OFFICE—254 W. 54th STREET, NEW YORK 19, N. Y.

Aerocrete Construction Co., Ltd., Lakefield Avenue, Montreal East, Quebec, Canada.

Research at Illinois

The University of Illinois Bulletin, No. 63, V. 46, "Research at Illinois," is an interesting and brief review of the research activities at the university. But it is more than a story of one research center, the activities pictured and problems covered relate to research, as carried out in all corners of the globe.

To quote from the bulletin, "Because men use instruments of measurement and control, the pictures in this booklet are often filled with impressive apparatus. The reader should not be misled by this circumstance. *Men* do research; apparatus assists them."

Topics covered include geology, molecular structure, life processes, technology, materials and structures, agriculture, foods and human behavior.

For a copy of the bulletin write University of Illinois Bulletin, Office of Publication, 358 Administration Bldg., Urbana, Ill.

Asbestos-cement pipe

"Engineering Facts about Transite Pressure Pipe" is a new 12-page booklet issued by Johns-Manville. It presents informative data about asbestos-cement pipe covering such items as capacity, joints, life expectancy and similar subjects of interest to engineers and others in the waterworks field. The booklet ends with tables on Transite pipe weights and dimensions.

Copies of "Engineering Facts about Transite Pressure pipe" are available from Johns-Manville, 22 East 40th Street, New York 16, N. Y.

Absorptive form lining

"Hydron Absorptive Form Lining," a 12-page booklet issued by United States Rubber Co., describes uses, installation and tests of Hydron form linings. The manufacturer states that the material is inexpensive, easy to ship, easy to store and easy to apply. The company also claims that the lining not only eliminates surface imperfections by absorption of air and water but actually increases surface density and abrasion resistance.

Further information can be obtained from United States Rubber Co., Mechanical Goods Division, 5850 Cass Avenue, Detroit 2, Mich.

Vermiculite

A Bureau of Mines report describes the location and accessibility of vermiculite deposits near Llano, Texas, and the history and production of the area including a detailed description of the character of the ore. It also gives the results of laboratory tests on the influence of temperature, moisture and flake size on exfoliation or swelling and the methods used to beneficiate the vermiculite.

Numerous tables supplement the text, together with maps and diagrams showing the location and form of the deposits.

A free copy of Report of Investigations 4486, "Investigation and Laboratory Testing of Vermicu-

lite Deposits, Llano County, Texas," may be obtained from the Bureau of Mines, Publications Distribution Section, 4800 Forbes St., Pittsburgh 13, Pa.

Rubber control joint strips

Williams Form Engineering Corp. has published a 4-page folder "Rubber Control Joint Strips." The leaflet gives design details and considerations in the location of control joints, the arrangement of reinforcement around openings where there are control joints, and form assembly when using rubber control joint strips.

A copy can be obtained from Williams Form Engineering Corp., 1501 Madison Ave., S. E., Grand Rapids 7, Mich.

Concrete forms and form hardware

A reprint of an article in *American Builder*, "Engineered House Construction," has been released by the Symons Clamp and Mfg. Co. The reprint supplies information on manufactured concrete forms and form hardware. Various systems are described in the text and photographs as well as rules of correct mixing and handling techniques for better concrete work.

A copy is available from Symons Clamp and Mfg. Co., 4249 W. Diversey Ave., Chicago 39, Ill.

New mixer

Chain Belt Co. announces the new Rex 3½ S skipper mixer. The company claims the new mixer will give 50 percent greater production than the 3½ S tilter type mixer. A stationary charging gate allows loading the hopper while another batch is in the drum. Easy operating, grouped controls add to the efficiency of the mixer. The skip lever acts as the skip shaker arm to get the batch into the drum.

Bulletin 49-16 lists specifications and illustrations and is available from Chain Belt Co., 1600 West Bruce St., Milwaukee 4, Wis.

Franklin Institute

A new brochure issued by the Franklin Institute of the State of Pennsylvania describes the facilities of its research and development laboratories. Well illustrated, the publication describes the metallographic, radiation, friction, high polymer, etc. research carried on by the Institute, and pictures many of the instruments used.

Copies of the brochure may be obtained by writing to Administration Division, The Franklin Institute Laboratories for Research and Development, Benjamin Franklin Parkway at 20th Street, Philadelphia 3, Pa.

Installing counter flashing

A leaflet released by the Fry Reglet Co. describes a method of installing the Fry Flashing Reglet in concrete and masonry construction. The Reglet is a rolled metal section built in the wall. Counter flashing is inserted in the reglet and sealed with plastic rope against leakage. Sequence diagrams of installation are included.

A copy may be obtained from Fry Reglet Co., Division of Watts Electric and Mfg. Co., Birmingham, Mich.

New Members

Continued from p. 12

Cuba

Garmendia y Carrera, Jose M., (Indiv.) Edificio "Lopez Serrano", Ap. 85, 13 No. 108, Vedado, Havana, Cuba

Santo-Tomas, Humberto, (St.) 17 No. 560 esq. a C, Vedado, Havana, Cuba

Solis, Manuel M., (St.) Calle 17 No. 605, Vedado, Havana, Cuba

Dominican Republic

Delgado, Ramon A., (Jr.) Valverde - Mao, Dominican Republic, W. I.

England

Heaton, Joseph, (Indiv.) 21, Sutcliffe Ave., Nunsthorpe, Grimsby, Lincs., England

Meers, Albert Winston, (Jr.) 57 Beauchamp Rd., Billesley, Birmingham 14, England

Waryeha, Ludwik, (Indiv.) 147 Coningham Rd., London W. 12, England

Holland

Van Themaat, R. Verloren, Jr., (Indiv.) Pater Brugmanstraat 2, Nymegen, Holland

Mexico

Leroy, Robert, (Indiv.) Matamoros Ote 427-5, Torreon, Coah., Mexico

Panama

Mendez, Guillermo, Jr., (Indiv.) P. O. Box 590, Panama City, Panama

What Makes Buzzie write Like tH is?

BUZZIE is just learning to write. And every line he writes starts out with big letters and ends up with little ones.

The trouble is, he doesn't plan ahead. He just concentrates on those big letters.

Many grownups have the same trouble—not with their handwriting, but with their money.

That's why the Payroll Savings and Bond-A-Month Plans are such a blessing. They're "human-nature-proof." The saving is done *for* you—automatically

And remember, U. S. Savings Bonds bring you $4 for every $3 invested.

So don't let your life run on like Buzzie's handwriting. Sign up today for Payroll Savings—or, if you're not on a payroll, the Bond-A-Month Plan at your bank.

Automatic saving is sure saving — U.S. Savings Bonds

Current ACI Standards

Recommended Practice for the Application of Portland Cement Paint to Concrete Surfaces (ACI 616-49)
16 pages in covers: 50 cents per copy (40 cents to ACI Members)

Building Code Requirements for Reinforced Concrete (ACI 318-47)
64 pages in covers: 50 cents per copy (40 cents to ACI Members)

Minimum Standard Requirements for Precast Concrete Floor Units (ACI 711-46)
16 pages in covers: 50 cents per copy (40 cents to ACI Members)

Recommended Practice for the Construction of Concrete Farm Silos (ACI 714-46)
16 pages in covers: 50 cents per copy (40 cents to ACI Members)

Recommended Practice for the Design of Concrete Mixes (ACI 613-44)
24 pages in covers: 50 cents per copy (40 cents to ACI Members)

Specifications for Cast Stone (ACI 704-44)
4 pages: 35 cents per copy

Specifications for Concrete Pavements and Bases (ACI 617-44)
30 pages in covers: 50 cents per copy (40 cents to ACI Members)

Recommended Practice for Measuring, Mixing and Placing Concrete (ACI 614-42)
30 pages in covers: 50 cents per copy (40 cents to ACI Members)

Recommended Practice for the Use of Metal Supports for Reinforcement (ACI 319-42)
4 pages: 35 cents per copy

Manual of Standard Practice for Detailing Reinforced Concrete Structures (ACI 315-48)
A publication of large format, bound to lie flat.
55 pages: $3.00 per copy ($1.75 to ACI Members)

Recommended Practice for Winter Concreting Methods (ACI 604-48)
20 pages in covers: 50 cents per copy (40 cents to ACI Members)

SYNOPSES of recent ACI Papers and Reports

Institute papers of this JOURNAL Volume 21 are currently available at prices indicated. Please order by title and title number.

RECOMMENDED PRACTICE FOR THE APPLICATION OF PORTLAND CEMENT PAINT TO CONCRETE SURFACES (ACI 616-49) 46-1

Price 50 cents (in special covers).

REPORT of COMMITTEE 616—Sept. 1949, pp. 1-16 (V. 46)

Supersedes 38-30 and 45-18.

This ACI standard establishes recommended practices for appropriate usage, age of concrete, preparation of surface, and the preparation, application and curing of portland cement paint. Three appendixes discuss composition, manufacture and storage, and general characteristics and factors affecting durability.

AN ULTRASONIC METHOD OF STUDYING DETERIORATION AND CRACKING IN CONCRETE STRUCTURES.....46-2

Price 35 cents.

J. R. LESLIE and W. J. CHEESMAN—Sept. 1949, pp. 17-36 (V. 46)

A new method and apparatus for field and laboratory testing of concrete is described. The apparatus called the "Soniscope" was originally designed to detect internal cracks in concrete. It develops pulses of ultrasonic sound in the material and measures the velocity of their transmission through it. This pulse velocity has the unique advantage of being independent of the size or shape of the body under test. Measurements can be made with equal facility in mass concrete, slabs or laboratory specimens.

The existence and extent of internal cracks and the depth of visible surface cracks can be determined by the use of this apparatus.

The velocity has been found, by experiment, to be a reliable measure of the condition of the concrete and is particularly useful in deterioration studies. The dynamic modulus can be calculated from this velocity, and values so obtained are found to agree closely with the results of tests using established methods.

MANUFACTURE OF REINFORCED FOAM CONCRETE ROOF SLABS...46-3

Price 35 cents.

I. T. KOUDRIASHOFF—Sept. 1949, pp. 37-48 (V. 46)

The Russian type of lightweight concrete described used a rosin-glue emulsion to preserve the air voids before the initial set of the cement. Shrinkage was decreased and strength increased through high pressure steam curing. The autoclave treated foam concrete used in the production of precast industrial roof slabs had a unit weight of 47 lb per cu ft and a compressive strength of over 500 psi. The lightweight slabs, used in a load carrying capacity and as insulation, reduced construction time by 50 percent and costs by as much as 20 percent. Test data on roof slabs and production procedures are also described.

SUGGESTIONS ON CONCRETE FLOOR CONSTRUCTION 46-4

Price 35 cents.

ERNST GRUENWALD—Sept. 1949, pp. 49-56 (V. 46)

The relationship between good concrete floors and the proper selection of cement and aggregates is discussed. Data are cited to emphasize the advantage of coarse-aggregate mixes over cement-sand topping for concrete floors.

USE OF AIR-ENTRAINING CONCRETE IN CANAL LINING 46-5

Price 35 cents.

JOSEPH J. WADDELL—Sept. 1949, pp. 57-64 (V. 46)

This paper presents a discussion based on field observations of the use of air entrainment in canal lining concrete. The Bureau of Reclamation made studies of air-entraining agents for use in the irrigation canal lining for the Friant-Kern Canal on the Bureau's Central Valley Project in California. Results to date indicate that appreciable benefits accrue when an air-entraining agent is used in concrete which is placed and compacted by means of a mechanical slip-form. Care is necessary in adjusting concrete mixes to incorporate entrained air because of the sensitivity to mix changes of concrete for slip-form placement.

THE USE OF PORTLAND-POZZOLAN CEMENT BY THE BUREAU OF RECLAMATION..46-6

Price 35 cents.

ROBERT F. BLANKS—Oct. 1949, pp. 89-108 (V. 46)

The Bureau of Reclamation has made extensive studies of pozzolanic materials, and portland-pozzolan cements are now being used in many of the major structures built by the Bureau. The properties of portland-pozzolan cement that are used advantageously in the production of mass concrete are described.

RESISTANCE OF CONCRETE AND PROTECTIVE COATINGS TO FORCES OF CAVITATION.....46-7

Price 35 cents.

WALTER H. PRICE and GEORGE B. WALLACE—Oct 1949, pp. 109-120 (V. 46)

A machine used for producing cavitation erosion in the laboratory is described and the results of tests made to investigate the effect of mix proportions, surface treatment, and protective coatings on the resistance of concrete to cavitation are discussed. Through proper use of these, the resistance of concrete surfaces to cavitation erosion may be extended three or four times, but even the best concrete will not resist the forces of cavitation for a prolonged period. Heavy rubber coatings bonded well to the surface of the concrete have proved effective.

VACUUM PROCESSES APPLIED TO PRECAST CONCRETE HOUSES...46-8

Price 35 cents.

K. P. BILLNER and BERT M. THORUD—Oct. 1949, pp. 121-128 (V. 46)

The use of vacuum processes in precast concrete construction simplifies the building of fire-resistant, durable structures designed to permit the maximum use of like units. Vacuum processes have thus far been used in one- and two-story houses and one-story industrial or warehouse structures, but further developments should make possible similar benefits for multi-story construction.

The specific vacuum methods utilized are: (1) extracting excess water from freshly placed concrete prior to set, thereby increasing early strength and enabling early handling of units, (2) holding forms in place by vacuum and (3) handling and placing finished and hardened concrete units by cast-in-place closures formed and quickly hardened by vacuum processes.

The use of these methods results in high strength monolithic construction having exterior and interior finished surfaces, with insulation incorporated into the construction, if desired.

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Synopses

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NEW TYPE OF CONSISTENCY METER TESTED AT ALLATOONA DAM.....46-9

Price 35 cents.

JAMES M. POLATTY—Oct. 1949, pp. 129-136 (V. 46)

Various mechanical devices have been developed for indicating consistency of concrete since the early days of visual inspecition after discharge from the mixer. A new type meter to measure the consistency of concrete while it is being mixed was tested at Allatoona Dam and the operation and results are described.

EFFECT OF MIXING SEQUENCE ON THE PROPERTIES OF CONCRETE....46-10

Price 35 cents.

F. L. FITZPATRICK and W. SERKIN—Oct. 1949, pp. 137-140 (V. 46)

The order in which the constituents of concrete (aggregates, cement and water) are combined in the mixing operation, has a significant effect upon the properties of the concrete as to workability, strength, density, surface finish and absorption. Tests are reported.

DISCUSSION

Discussion closes January 1, 1950

Sept. Jl. '49

Recommended Practice for the Application of Portland Cement Paint to Concrete Surfaces (ACI 616-49)—Report of Committee 616

An Ultrasonic Method of Studying Deterioration and Cracking in Concrete Structures—J. R. Leslie and W. J. Cheesman

Manufacture of Reinforced Foam Concrete Roof Slabs—I. T. Koudriashoff

Suggestions on Concrete Floor Construction—Ernst Gruenwald

Use of Air-Entraining Concrete in Canal Lining—Joseph J. Waddell

Discussion closes February 1, 1950

Oct. Jl. '49

The Use of Portland-Pozzolan Cement by the Bureau of Reclamation—Robert F. Blanks

Resistance of Concrete and Protective Coatings to Forces of Cavitation—Walter H. Price and George B. Wallace

Vacuum Processes Applied to Precast Concrete Houses—K. P. Billner and Bert M. Thorud

New Type of Consistency Meter Tested at Allatoona Dam—James M. Polatty

Effect of Mixing Sequence on the Properties of Concrete—F. L. Fitzpatrick and W. Serkin

Further studies are presented on the

Bond of Concrete Reinforcing Bars*

By ARTHUR P. CLARK†

SYNOPSIS

The tests reported were made to compare the resistance to slip in concrete (bond) of deformed bars when tested in beams and companion pull-out specimens, to secure information on the effects of size of bar, the type of deformations on the bars and the strength of concrete on the bond. The bars were cast in a horizontal position in all test specimens. The variables were depth of concrete under the bar, length of embedment of the bar in the concrete, strength of concrete and diameter of bar. Slip of the bar was measured at the loaded and free ends. Three tests were made with 2 in. of concrete under the bar, with 15 in. of concrete under the bar and with 8-in., 12-in., and 16-in. embedments.

Bond strengths for the beams and the pull-out specimens were affected similarly by changes in the geometry of the bars and the bond test specimens. They were greater when the bars were near the bottom than when they were near the top of the specimens. The highest bond strengths were obtained with bars having deformations conforming to suggested requirements for maximum spacing and minimum height and providing ratios of shearing to bearing areas less than 10, usually less than 6.

INTRODUCTION

The primary purpose of the tests, made at the National Bureau of Standards under a Research Fellowship for the Committee on Reinforced Concrete Research of the American Iron and Steel Institute, was to determine the bond value of concrete reinforcing bars when tested in beam specimens in accordance with the "Proposed Test Procedure to Determine Relative Bond Value of Reinforcing Bars,"‡ ACI Committee 208, Bond Stress. Additional objectives were to determine the correlation between the results of the beam and the pull-out tests made at the same time and under identical conditions, to secure infor-

*Received by the Institute Sept. 26, 1949. Title No. 46-11 is a part of copyrighted JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, V. 21, No. 3, Nov. 1949, *Proceedings* V. 46. Separate prints are available at 35 cents each. **Discussion** (copies in **triplicate**) should reach the Institute not later than Mar. 1, 1950. Address 7400 Second Boulevard, Detroit 2, Mich.

†Member American Concrete Institute, Research Associate, Fellowship of American Iron and Steel Institute at the National Bureau of Standards, Washington, D. C.

‡"Proposed Test Procedure to Determine Relative Bond Value of Reinforcing Bars," ACI JOURNAL, Feb. 1945, *Proc.* V. 41, p. 273.

mation as to the influence of size of bar and strength of concrete on bond and to test the experimental designs of deformations made by manufacturers in their efforts to produce bars having bond resistance approaching the maximum consistent with economical commercial production.

MATERIALS

Reinforcing bars

The bars in the tests were nominally ½-in. round, ⅞-in. round, and 1⅛-in. square. The areas of the bars and details of the deformations are given in Table 1. All ⅞-in. bars, except bar No. 16, and one ½-in. bar (No. 15) are illustrated in Fig. 1a and 1b. Bar No. 16 was the same as bar No. 11 except for the height of deformations. The bars

TABLE 1—DETAIL DIMENSIONS OF BARS

Bar			Deformations				
Size, in.	No.	Area, sq in.	Average spacing, in.	Average height, in.	Bearing area, sq in. per in.	Shearing area, sq in. per in.	Ratio of shearing to bearing area
½	2	0.200	1.234	0.018	0.013	0.835	64.2
½	5	0.200	0.371	0.038	0.139	1.225	8.7
½	6	0.198	0.368	0.027	0.100	1.160	11.6
½	8	0.200	0.250	0.031	0.191	1.149	6.0
½	11	0.196	0.209	0.028	0.217	1.382	6.4
½	13	0.202	0.443	0.030	0.094	1.306	13.9
½	15	0.200	0.206	0.041	0.245	0.795	3.2
⅞	1	0.603	0.671	0.056	0.148	1.792	12.1
⅞	2	0.599	1.412	0.032	0.040	1.621	40.1
⅞	3	0.591	0.667	0.060	0.185	2.063	11.2
⅞	4	0.599	0.656	0.050	0.177	2.085	11.8
⅞	5	0.599	0.581	0.057	0.232	2.313	10.0
⅞	6	0.606	0.606	0.058	0.248	2.629	10.6
⅞	7	0.610	0.375	0.033	0.161	2.208	13.8
⅞	8	0.610	0.380	0.050	0.355	2.100	5.9
⅞	9	0.597	Plain—No deformations				
⅞	10	0.578	0.398	0.047	0.276	1.981	7.2
⅞	11	0.615	0.368	0.045	0.305	1.930	6.3
⅞	12	0.605	0.296	0.040	0.327	1.867	5.7
⅞	13	0.594	0.762	0.070	0.242	2.460	10.2
⅞	14	0.605	0.434	0.062	0.359	1.956	5.5
⅞	17	0.594	0.633	0.054	0.207	2.234	10.8
1⅛	2	1.268	1.735	0.034	0.069	3.281	47.6
1⅛	5	1.245	0.921	0.074	0.282	3.500	12.4
1⅛	6	1.210	0.944	0.063	0.263	3.139	11.9
1⅛	8	1.268	0.544	0.072	0.522	3.373	6.5
1⅛	11	1.269	0.525	0.052	0.385	3.298	8.6
1⅛	13	1.254	1.115	0.078	0.416	5.281	12.7
1⅛	15	1.278	0.517	0.083	0.479	2.906	6.1
1⅛	16	1.274	0.475	0.071	0.589	2.888	4.9
1⅛	18	1.269	1.255	0.036	0.084	2.737	32.7

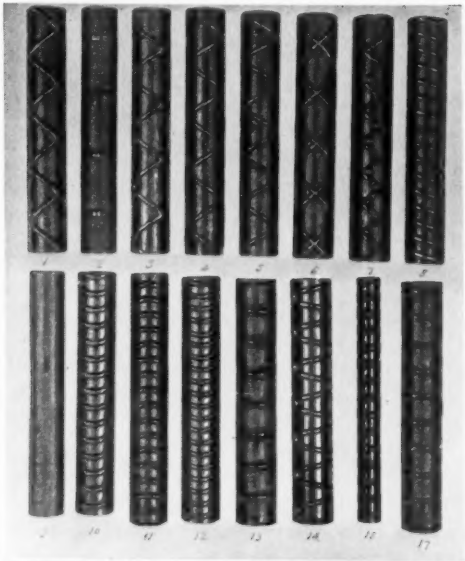


Fig. 1a—Types of bars tested

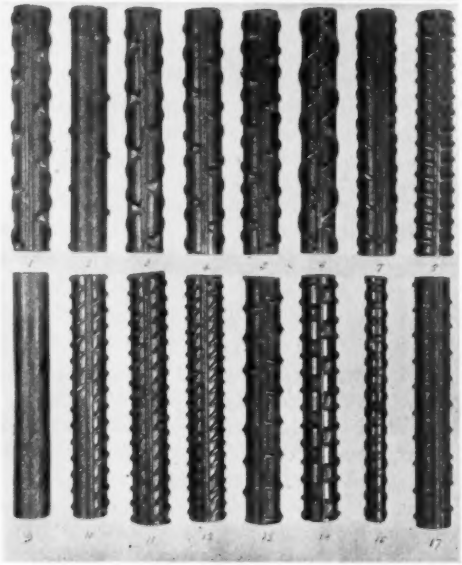


Fig. 1b—Types of bars tested

nominally 1⅛-in., with two exceptions described below, were round in cross section with areas equal to 1⅛-in. square bars. Bars No. 2 and 18 were square in cross section and of a type similar to the ⅞-in. round bar No. 2.

With the exception of the plain bar (No. 9) all bars were deformed and were similar in type to those included in tests previously reported* but some had improved deformations. The plain bar and one unimproved deformed bar (No. 2) of a type heretofore in general use were included in these tests for the purpose of comparison.

Concrete

Concrete was machine mixed and rodded when placed in the molds. One brand of cement, from the same mill, which met the current A.S.T.M. standard specification for Type I portland cement was used throughout. Coarse aggregate was Potomac River gravel ranging in size from No. 4 to 1-in. The fine aggregate was Potomac River sand described in the previous series.* There were three concretes of different mixes which are hereafter referred to as 6000, 3500 and 2000-lb concretes. The first concrete proportioned by weight in the ratio 1:1.4:2.0 with water-cement ratio of 5.15 gal. per sack gave an average compressive strength for 6 x 12-in. cylinders at 28 days of 6030 psi and an average slump of 5.5 in. The second concrete proportioned 1:2.91:4.04 with 8.7 gal. of water per sack averaged 3570 psi with a slump of 4.8 in. The third concrete proportioned 1:3.97:5.15 with 11.77 gal. of water per sack averaged 1840 psi with a slump of 4.5 in.

DESCRIPTION OF TEST SPECIMENS

Beam specimens were 8 x 18 in. in cross section and 78 in. over-all length. Two notches 6 in. long and 3 in. high near each end exposed the reinforcing bar. Half of the specimens were cast with the bar held 2 in. from the bottom of the mold and the other half with the bar held 2 in. from the top. The molds were of steel and fabricated in accordance with the details given in the report of ACI Committee 208.

Pull-out specimens were 8 x 9 in. in cross sections and 8, 12 and 16 in. long. Two specimens were cast, with the bars in a horizontal position, in a mold 18 in. deep with one bar held near the bottom and one near the top comparable to the positions in the beams. At the end of two days the block was removed from the mold and separated into two specimens. The molds were made of heavy steel sections and sealed to prevent leakage.

*Clark, Arthur P., "Comparative Bond Efficiency of Deformed Concrete Reinforcing Bars," ACI JOURNAL, Dec. 1946, *Proc.* V. 43, p. 381.

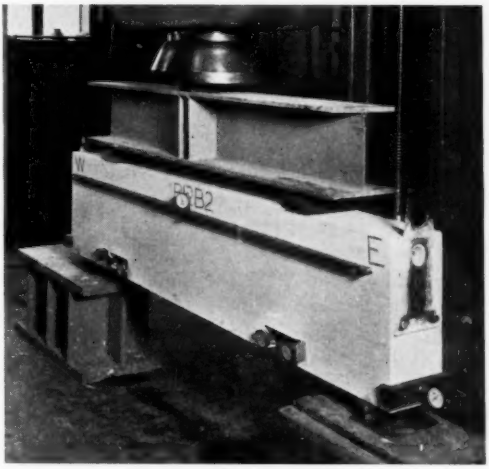


Fig. 2—Beam specimen in testing machine

TESTING PROCEDURE

The beams were tested in a 600,000 lb capacity hydraulic testing machine on supports 72 in. apart, the supports being a roller at one end and a spherical bearing unit at the other end (Fig. 2). The load was applied through a steel loading beam with a roller at one load point and a spherical bearing unit at the other load point. The load points were adjusted at 8, 12 and 16 in. from the supports. The distances of the load points from the supports thus corresponded to the three lengths of embedment of the bar. The load points in each case were directly over the outer edges of the 6-in. notches which exposed the bar. In these notches two yokes were clamped into drilled contact points on 5 in. centers on each side of the bar. Dial gages attached to the yokes permitted measurement of the strain in the bar. The gage on the reaction side of the notch bore on a steel angle clip attached with a screw to the concrete at the edge of the notch; this gage measured the slip of the bar directly under the load (loaded end slip). Dial gages at each end of the beam, held in position by steel yokes, clamped to the concrete, measured the slip at the end (free end slip) of the bar. Deflection at the center of the beam was measured by a dial gage supported by an aluminum bar whose ends were attached to the sides of the beam over the supports; this gage bore on an angle clip attached with a screw to the concrete. The specimens which were cast with the bar held 2 in. from the top were turned upside down in testing. The beams were removed from the mold five days after casting and kept moist until tested at the age of 28 to 30 days.

Pull-out specimens were tested in a 60,000 lb. capacity universal hydraulic testing machine. The specimen was seated on a rubber cushion on two segments of a 2-in. base plate attached to a spherical bearing block. Slip of the bar was measured with 0.0001-in. micrometer dial gages and estimated to 0.00005 in. At the loaded end two dial gages were held by a steel bar attached to the bottom face of the specimen by bolts secured into inserts cast in the specimen. The gages were in contact with a steel yoke fastened to the reinforcing bar 1 in. below the surface of the concrete. The support bar for the gages and the yoke were free to move in the recess in the base plate. The average of the two gage readings indicated the amount of movement of the point on the reinforcing bar at which the yoke was attached with reference to the lower face of the concrete. To give the slip at the face of the concrete (slip at loaded end), the gage readings were corrected for the elongation of the reinforcing bar in the 1-in. distance between the point of attachment of the yoke, and the face of the concrete.

The slip at the free end was read directly from the gage mounted on a support, seated in plaster, on the top of the specimen with the point of the dial resting on the planed end of the bar.

With the $\frac{7}{8}$-in. bars, 18 beam and 18 pull-out tests were made for each type of bar, 3 each with the bar in the botton and top positions and with 8- 12- and 16-in. embedments. With $\frac{1}{2}$-in. and $1\frac{1}{8}$-in. bars 12 tests were made, 3 each in the bottom and top positions and with 8- and 12-in. embedments for the $\frac{1}{2}$-in. and with 12- and 16-in. embedments for the $1\frac{1}{8}$-in. bar.

RESULTS AND DISCUSSIONS

Beams generally failed in bond although with the longer embedments diagonal tension failure combined with bond failure occurred with some specimens. The pull-out specimens failed by splitting of the concrete in all cases except with the plain bar.

The relation of bond stress to slip of bar as shown by the curves and the comparative charts is based in all cases, unless otherwise shown, on the average results for all tests and all lengths of embedment of the bar and for 3500-lb concrete.

The bond-slip relation of $\frac{7}{8}$-in. bars in beams, as measured at the loaded and free ends and for bottom and top cast bars, is shown in Fig. 3, 4, 5 and 6. The deflection at the center of beams with bottom cast bars for increasing loads for each of the three embedments of the bar is shown in Fig. 7, 8 and 9. Typical crack patterns after failure of the beam are shown in Fig. 10. The bond-slip relation of $\frac{7}{8}$-in. bars in pull-outs, for loaded and free ends and for bottom and top cast bars, is shown in Fig. 11, 12, 13 and 14.

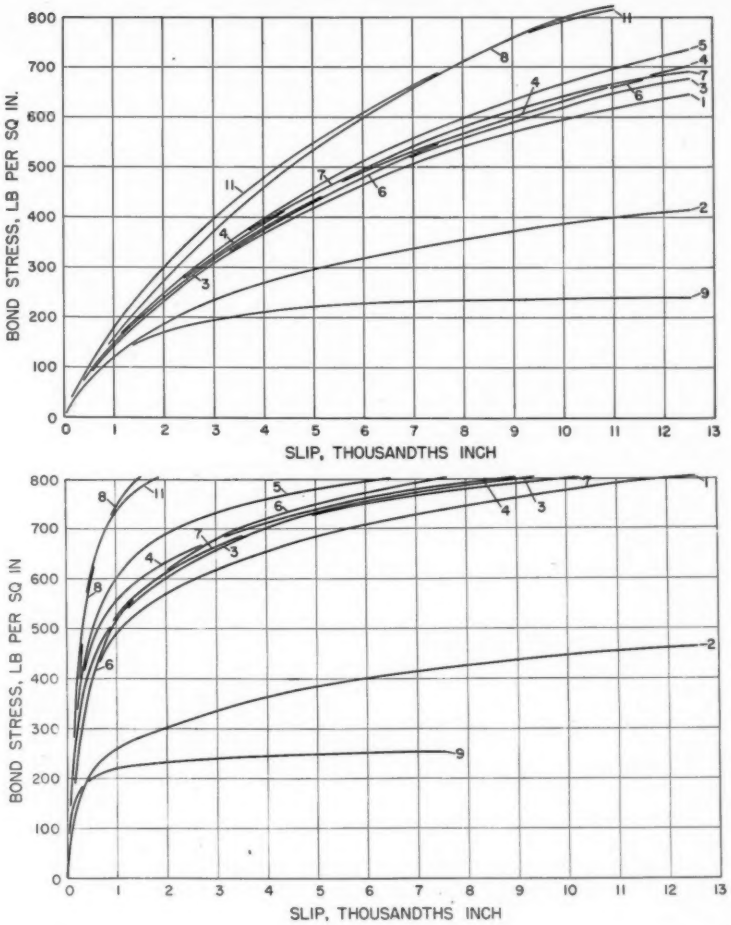
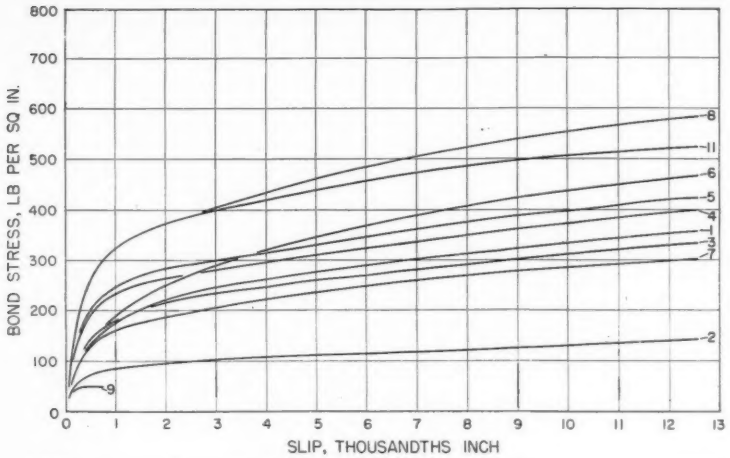


Fig. 3 (top)—Bond slip curves for $\frac{7}{8}$-in. bottom bars in beams, slip measured at loaded end

Fig. 4 (bottom)—Bond-slip curves for $\frac{7}{8}$-in. bottom bars in beams, slip measured at free end



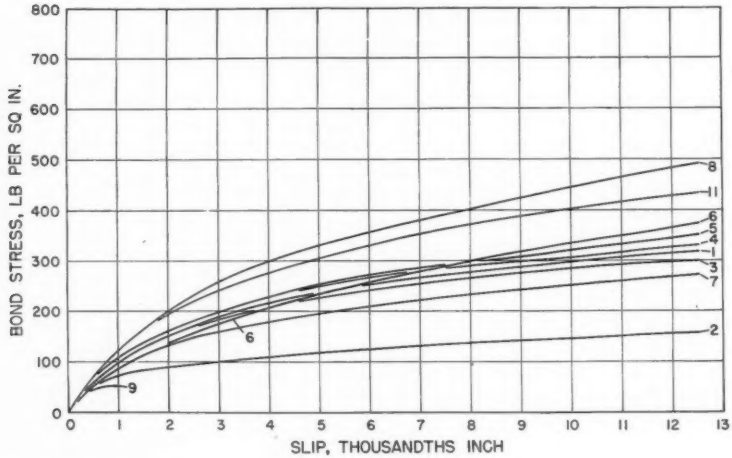


Fig. 5 (top)—Bond-slip curves for ⅞-in. top bars in beams, slip measured at loaded end

Fig. 6 (bottom)—Bond-slip curves for ⅞-in. top bars in beams, slip measured at free end

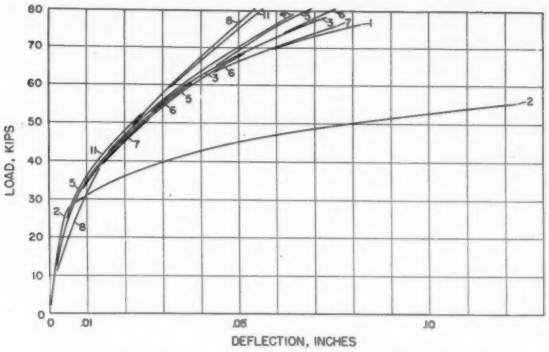


Fig. 7 — Deflection curves for beams with ⅜-in. bottom bars embedded 8 in.

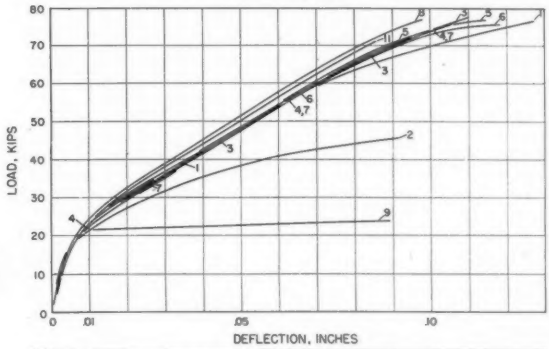


Fig. 8 — Deflection curves for beams with ⅜-in. bottom bars embedded 12 in.

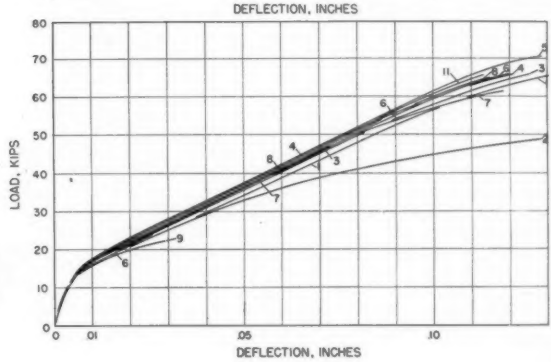


Fig. 9 — Deflection curves for beams with ⅜-in. bottom bars embedded 16 in.

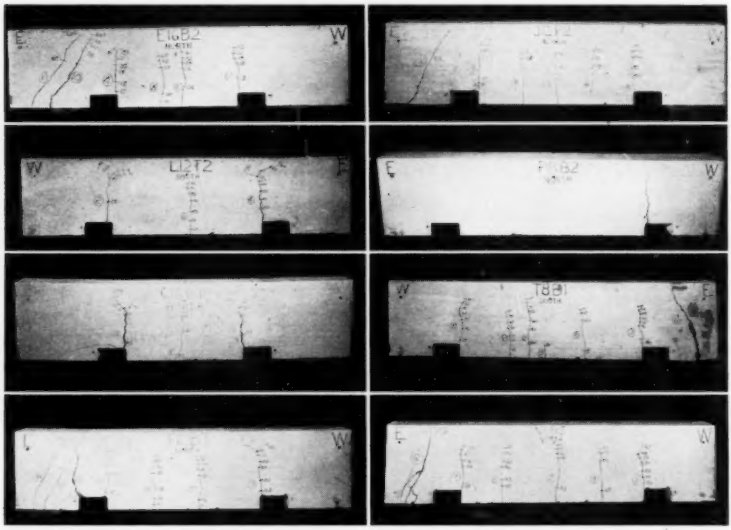


Fig. 10—Typical beam cracks at failure

Authorities considering the allowable stresses for bond to be permitted in design have used, by applying a suitable factor of safety, the average of bond stresses developed in tests at a slip of 0.01 in. at the loaded end and 0.005 in. at the free end. Fig. 15 represents the bond stresses at loaded end slip of 0.01 in. and free end slip of 0.005 in. and the average of the two as determined by beam and pull-out tests of $\frac{7}{8}$-in. bottom and top cast bars.

The average performance of a bar through a range of slip values was used to obtain a comparison of bond developed in beam specimens with that in pull-out specimens cast at the same time. The bond stresses for slips of 0.0005, 0.001, 0.002, 0.003, 0.004, 0.005, 0.0075 and 0.01 in. at the loaded end were totaled for each and divided by the number of slip values to give an average value. Slips of 0.00005, 0.0001, 0.0005, and 0.001 in. were used in a similar manner for free end comparison. The results for loaded end and free end slips, on the basis outlined above for all $\frac{7}{8}$-in. bars tested in both beam and pull-out specimens, shown in Fig. 16, indicated that the pull-out tests fairly represent the relative bonding efficiency of the bars. While the results for loaded and free end slips of top cast bars and free end slips of bottom cast bars were not as consistent as the results for loaded end slips of bottom cast bars, the load-slip relations were of similar form and show a consistent pattern

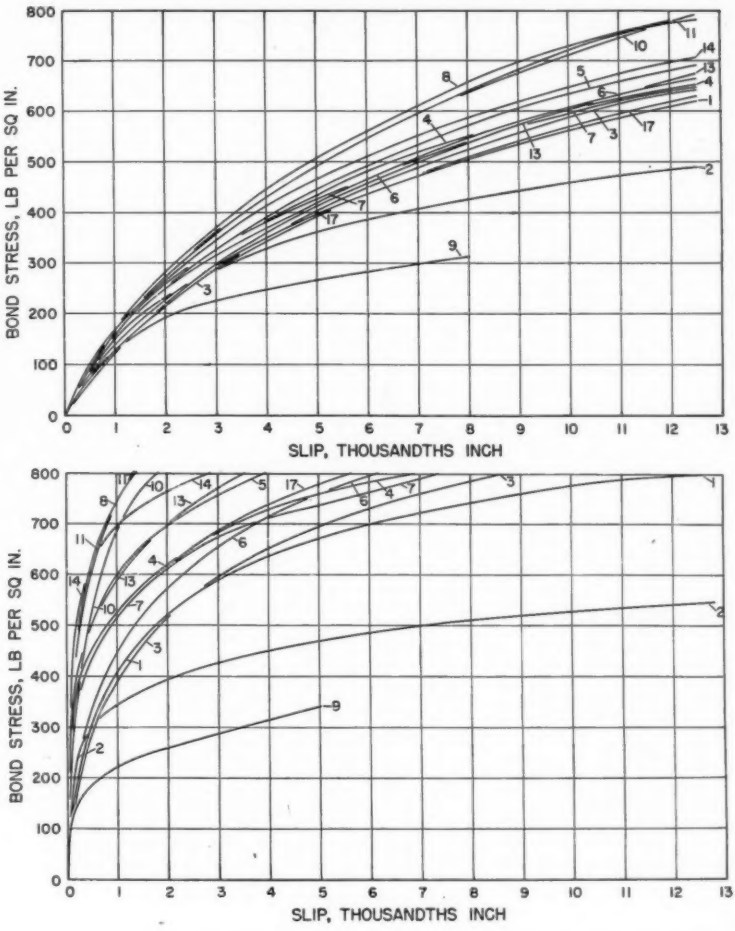
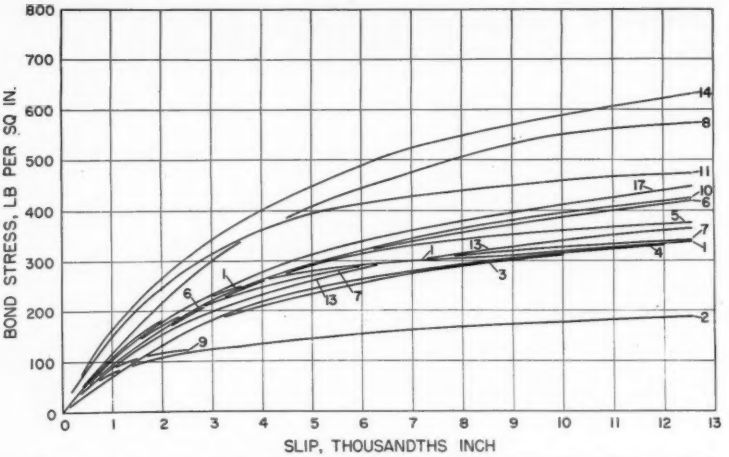


Fig. 11 (top)—Bond-slip curves for ⅜-in. bottom bars in pull-outs, slip measured at loaded end

Fig. 12 (bottom)—Bond-slip curves for ⅜-in. bottom bars in pull-outs, slip measured at free end



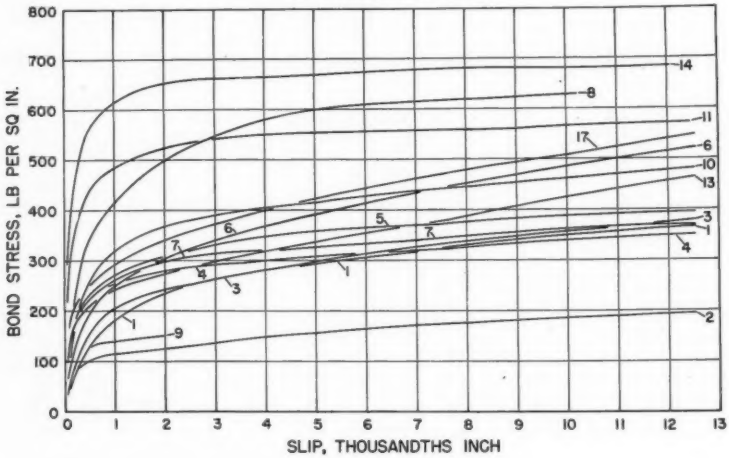


Fig. 13 (top)—Bond-slip curves for $\frac{7}{8}$-in. top bars in pull-outs, slip measured at loaded end

Fig. 14 (bottom)—Bond-slip curves for $\frac{7}{8}$-in. top bars in pull-outs, slip measured at free end

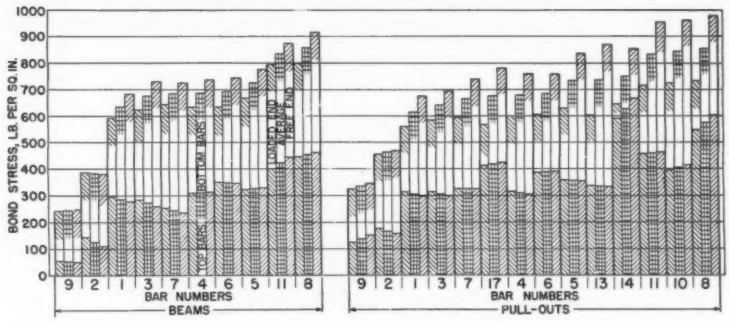


Fig. 15—Bond stresses for each ⅞-in. bar at loaded end slip of 0.01 in., free end slip of 0.005 in. and average of the two for bottom and top bars in beams and pull-outs

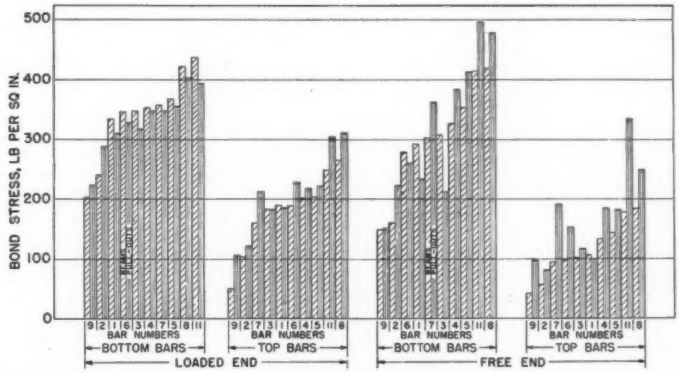


Fig. 16—Comparison of beam and pull-out tests of each ⅞-in. bar in bottom and top positions based on the average of bond stresses at slips of 0.0005, 0.001, 0.002, 0.003, 0.004, 0.005, 0.0075 and 0.01 in. measured at loaded end and the average at slips 0.00005, 0.0001, 0.005 and 0.001 in. measured at free end

for all tests in both types of specimens. Fig. 17 gives a comparison of all bars in the series as tested in pull-out specimens for slips at the loaded end.

The bond-slip relation of the ½-in. and 1⅛-in. bars in pull-outs for loaded and free ends and bottom and top cast bars is shown in Fig. 18 to 25. The ½-in. bars were round while the 1⅛-in. bars were round in section with areas equal to that of a 1⅛-in. square, except bar 2 which was a 1⅛-in. square.

Results of tests of ½-, ⅞- and 1⅛-in. bars of type No. 6 are shown by the bond-slip curves of Fig. 26, 27, 28 and 29 for loaded and free ends, bottom and top cast and beam and pull-out specimens.

Pull-out tests of ½- and 1⅛-in. bars of type No. 6 in three concrete strengths are shown by the cruves of Fig. 30, 31, 32 and 33.

The Committee on Reinforced Concrete Research of the American Iron and Steel Institute after a study of the results of the first series of bond tests* sponsored the "Tentative Specifications for Minimum Requirements for the Deformations of Deformed Steel Bars for Concrete Reinforcement" A.S.T.M. Designation: A 305-47T. Data obtained during the present series of tests have resulted in putting before the A.S.T.M. for adoption two revisions of the above tentative specifications; one changing the maximum average spacing of the deformations to seven-tenths of the nominal size of the bar, and the other changing the minimum height of deformations to 4½ percent of the nominal size for ⅝-in. bars and to 5 percent for bars ¾-in. and larger.

The following bars met the requirements of the proposed revised specification, A.S.T.M. A 305-47T: ⅞-in. bars 5, 6, 8, 10, 11 and 14; ½-in. bars 8, 11, 14 and 15; 1⅛-in. bars 8, 14, 15 and 16.

Text continued on p. 183

*Clark, Arthur P., "Comparative Bond Efficiency of Deformed Concrete Reinforcing Bars," ACI JOURNAL, Dec. 1946, *Proc.* V. 43, p. 381.

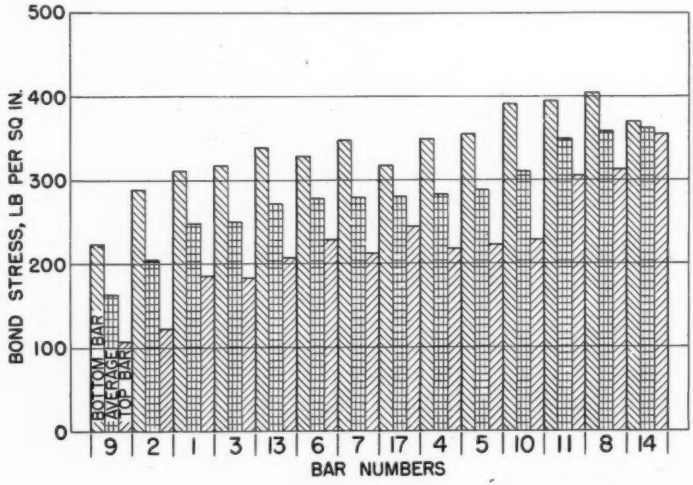
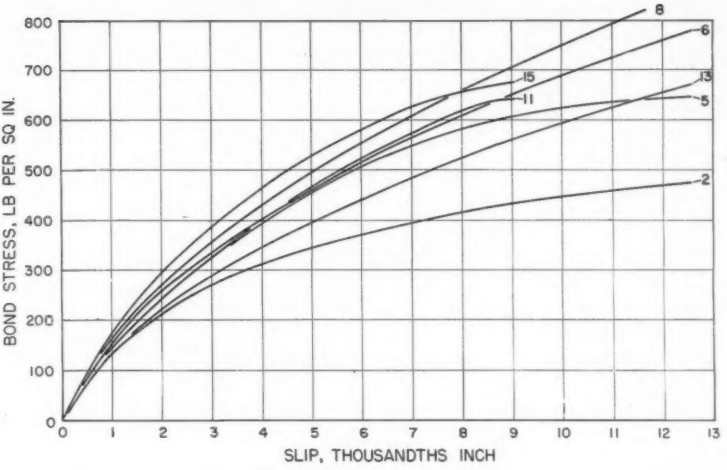


Fig. 17—Average of the bond stresses at slips of 0.0005, 0.001, 0.002, 0.003, 0.004, 0.005, 0.0075 and 0.01 in. measured at loaded end for each ⅞-in. bar in bottom and top positions in pullouts



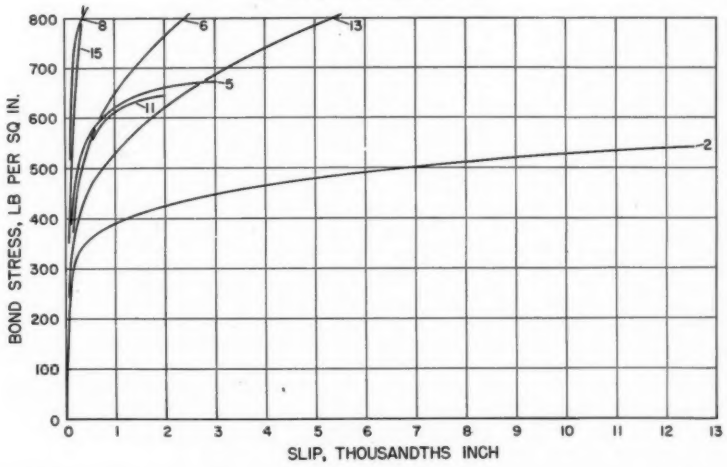
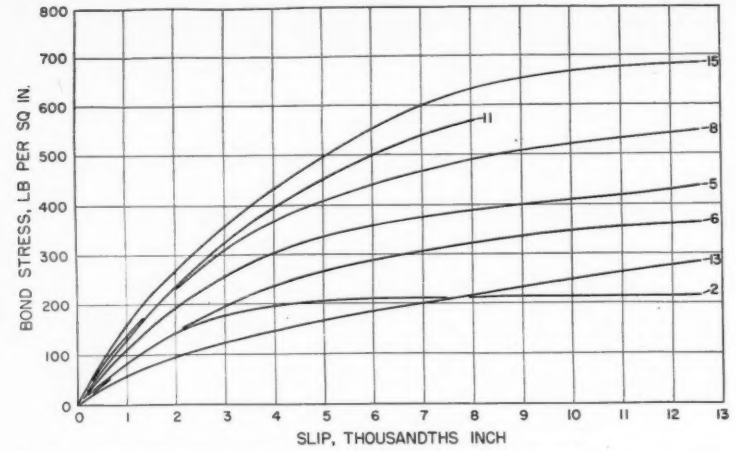


Fig. 18 (top)—Bond-slip curves for ½-in. bottom bars in pull-outs, slip measured at loaded end

Fig. 19 (bottom)—Bond-slip curves for ½-in. bottom bars in pull-outs, slip measured at free end



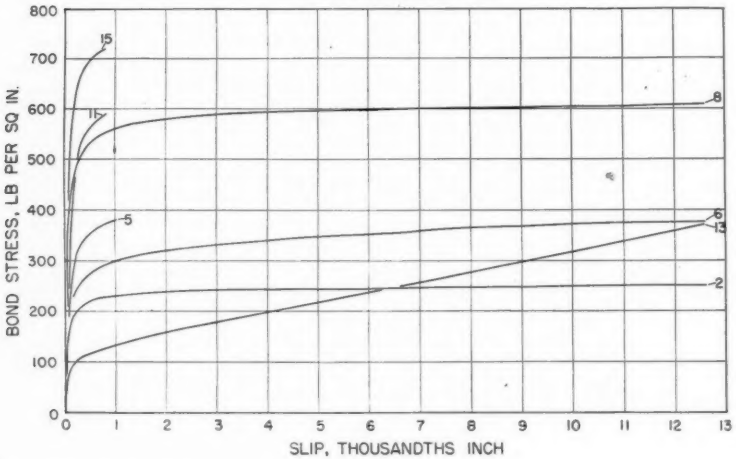
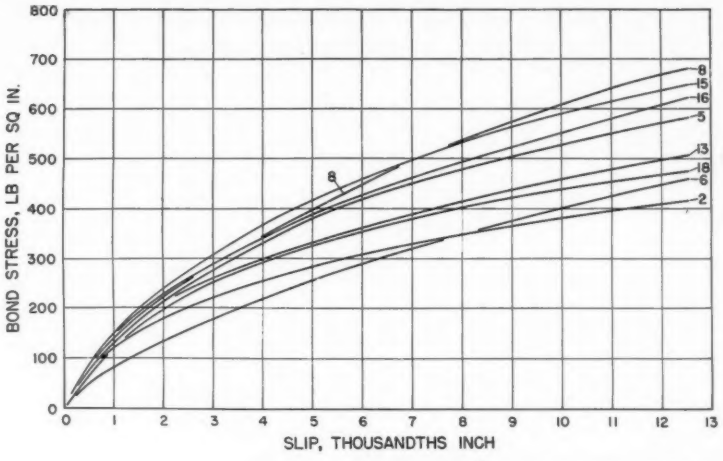


Fig. 20 (top)—Bond-slip curves for ½-in. top bars in pull-outs, slip measured at loaded end

Fig. 21 (bottom)—Bond-slip curves for ½-in. top bars in pull-outs, slip measured at free end



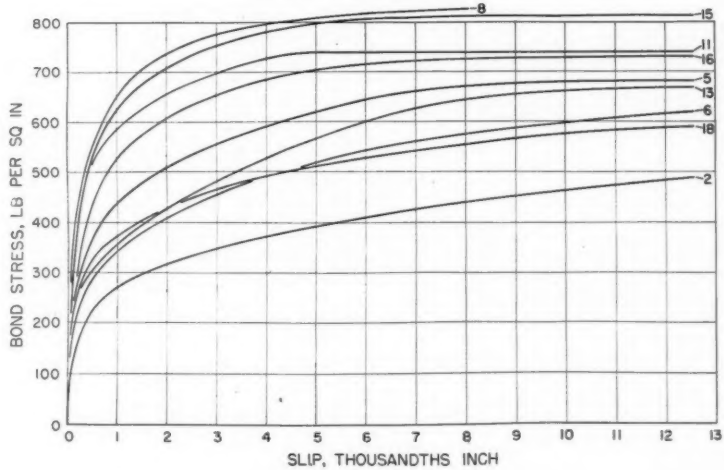
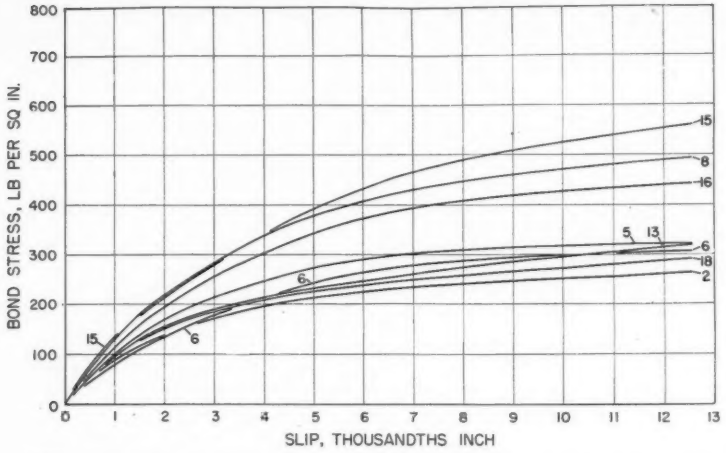


Fig. 22 (top)—Bond-slip curves for 1⅛-in. bottom bars in pull-outs, slip measured at loaded end

Fig. 23 (bottom)—Bond-slip curves for 1⅛-in. bottom bars in pull-outs, slip measured at free end



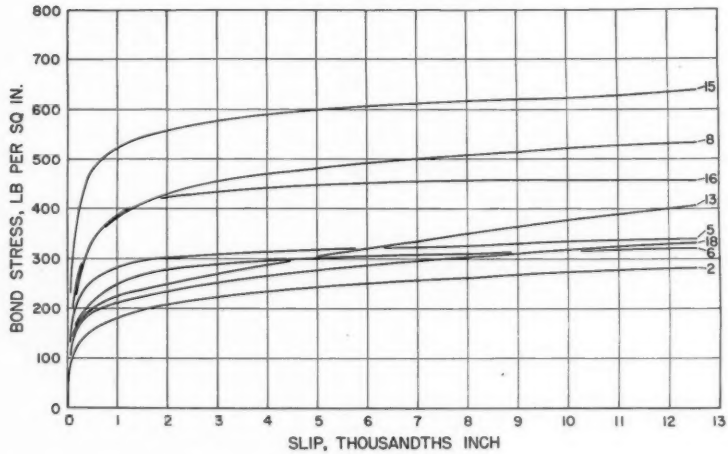
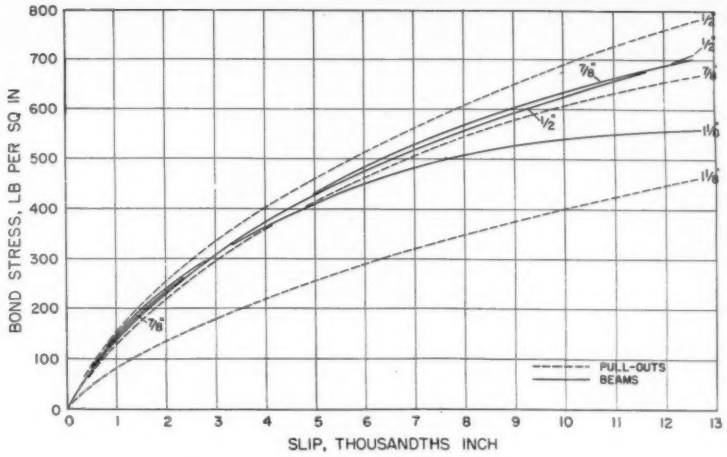


Fig. 24 (top)—Bond-slip curves for 1⅛-in. top bars in pull-outs, slip measured at loaded end

Fig. 25 (bottom)—Bond-slip curves for 1⅛-in. top bars in pull-outs, slip measured at free end



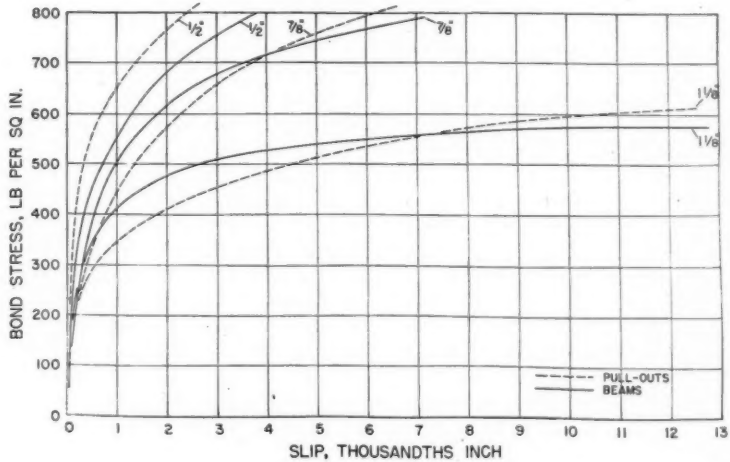
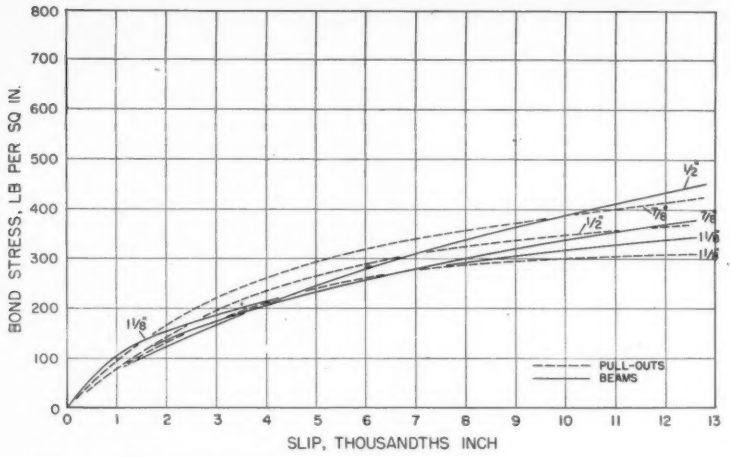


Fig. 26 (top)—Bond-slip curves for ½- ⅞- and 1⅛-in. bar No. 6, bottom cast, in beams and pull-outs, slip measured at loaded end

Fig. 27 (bottom)—Bond-slip curves for ½-, ⅞- and 1⅛-in. bar No. 6, bottom cast, in beams and pull-outs, slip measured at free end



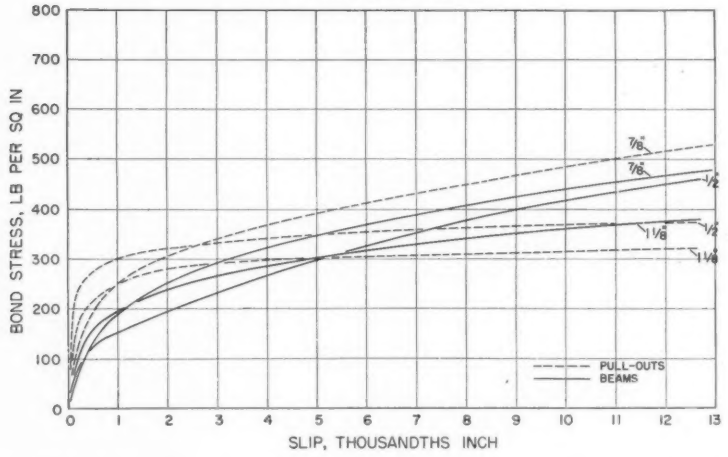
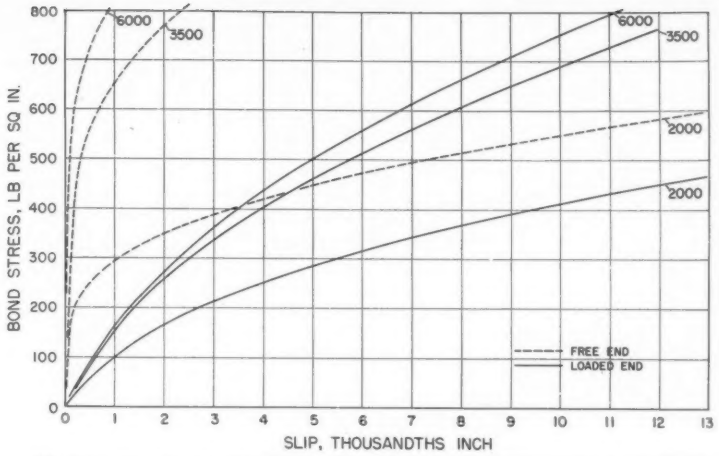


Fig. 28 (top)—Bond-slip curves for ½-, ⅞- and 1⅛-in. bar No. 6, top cast, in beams and pull-outs, slip measured at loaded end

Fig. 29 (bottom)—Bond-slip curves for ½-, ⅞- and 1⅛-in. bar No. 6, top cast, in beams and pull-outs, slip measured at free end



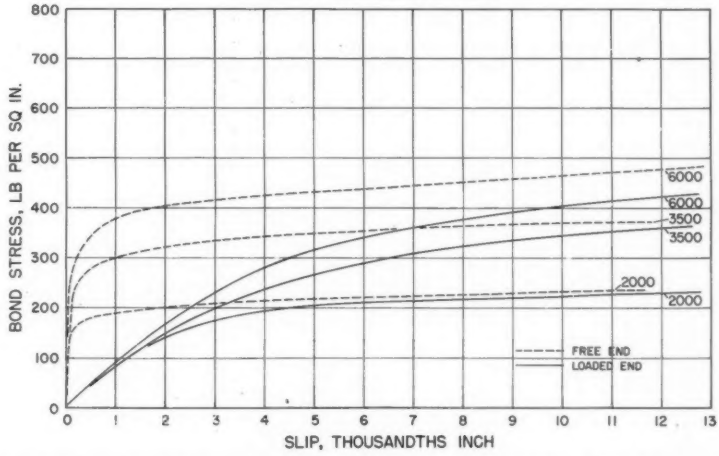
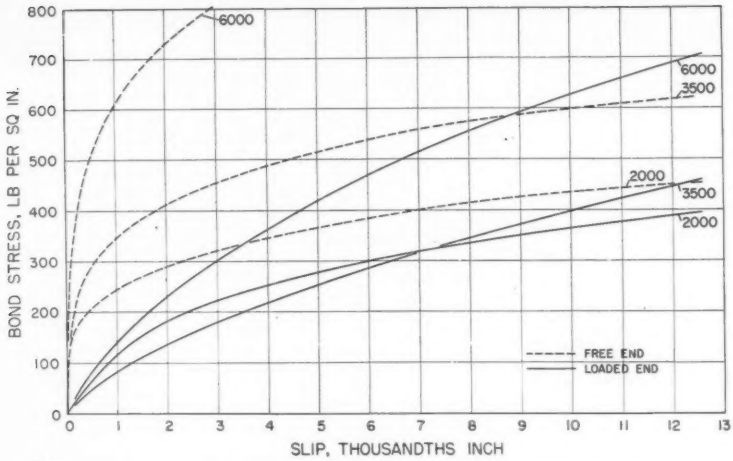


Fig. 30 (top)—Bond-slip curves for ½-in. bar No. 6 in 2000, 3500 and 6000 lb strength concretes, bottom cast, in pull-outs, slip measured at loaded and free ends

Fig. 31 (bottom)—Bond-slip curves for ½-in. bar No. 6 in 2000, 3500 and 6000 lb strength concretes, top cast, in pull-outs, slip measured at loaded and free ends



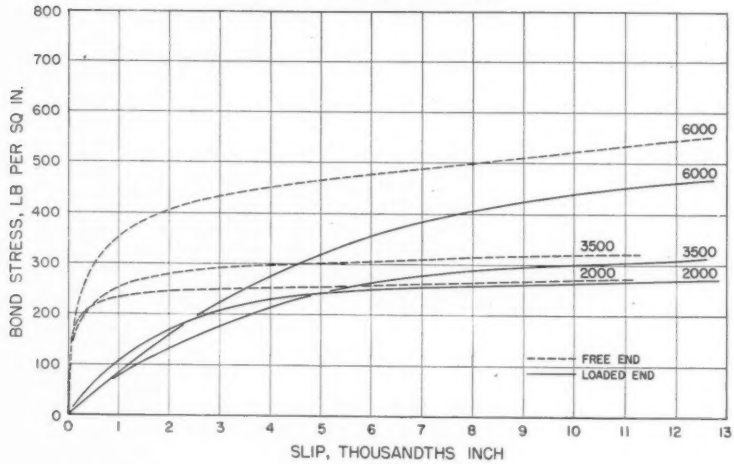


Fig. 32 (top)—Bond-slip curves for 1⅛-in. bar No. 6 in 2000, 3500 and 6000 lb strength concretes, bottom cast, in pull-outs, slip measured at loaded and free ends

Fig. 33 (bottom)—Bond-slip curves for 1⅛-in. bar No. 6 in 2000, 3500 and 6000 lb strength concretes, top cast, in pull-outs, slip measured at loaded and free ends

SUMMARY

Bond tests were conducted on both beam and pull-out specimens in which the bars were cast in a horizontal position. The specimens provided three lengths of embedment and two different depths of concrete under the bars. Slip of the bar was measured at both the loaded and the free end.

The results of the tests with both types of specimens were as consistent as expected for bond tests. The least consistent data were those pertaining to the slips at the free ends of the bars and for the bars cast in the top position.

The correlation between the results of the beam and the pull-out tests was such as to indicate that pull-out tests can give reliable estimates of the bonding efficiency of deformed reinforcing bars. Although the data obtained from the two types of specimens did not always rate the bars in the same order, the differences in ratings were usually too small to be of practical significance; moreover, the relations between load and slip were of similar form and the general behavior of the bars was similar in the two types of tests. The plain bar gave the least bond; the old type of deformed bar gave a somewhat higher bond and the rest of the bars gave still higher values, with those meeting the proposed revised A.S.T.M. Tentative Specification A 305-47T showing the highest bond.

The ratings of the bars were based upon the average performances for a range of slips at both the loaded and free ends, for either two or three lengths of embedment and with 2 in. or 15 in. of concrete beneath the bar as cast. The deformations of the bars which had the highest values of bond had bearing areas equal to or greater than the bearing area provided under A.S.T.M. A 305-47T limitations of maximum spacing, minimum height and length of deformations and the ratio of the shearing areas to bearing areas were less than 10. These results confirmed the previous observation that for good bond a maximum ratio of the shearing to bearing areas of 5 or 6 is desirable provided requirements of A 305-47T are met.

The bond strength obtained with bars conforming to the proposed specifications were much greater than those developed by bars in common use at the time ACI Committee 318 on Standard Building Codes determined the allowable bond stresses of the building code requirements for reinforced concrete. The superior performance of the bars of improved types was most marked when the conditions were least favorable for obtaining a strong bond, that is, with the bars in top position in the beams as cast.

ACKNOWLEDGMENTS

Albert E. Holbrook, Research Associate, was in charge of much of the laboratory procedure and the reduction of the extensive data developed in these tests. Timothy Miles, Jr., Laboratory Assistant, carried out the laboratory work with ingenuity and care. Acknowledgment is made and appreciation expressed for the willing cooperation and very helpful advise and assistance of the Bureau staff.

Answering many inquiries, data are reported on—

Perlite Aggregate: Its Properties and Uses*

By J. JOHN BROUK†

SYNOPSIS

Synthetic expanded volcanic rock, better known as perlite is a fairly recent addition to the lightweight aggregate field. Its use in concrete is governed by weight, gradation, mixing procedure, cellular structure, strength of cell walls, insulating properties, cost, etc. Air entrainment appears to be necessary to give a workable, nonsegregating mix. Perlite aggregate blended with sand can be used in high strength structural concrete and concrete products.

INTRODUCTION

Perlite as an aggregate in concrete is comparatively new. The rock from which it is manufactured has been defined as an obsidian of the same chemical composition as pumice, and can be classified as an acidic volcanic glass. The rock occurs in a variety of colors, but most varieties have a waxy or pearly lustre; its combined and uncombined water content varies up to 5 percent.

Perlite rock or ore has a specific gravity of about 2.4, has a silica content of 68 to 74 percent, and an alumina content of 11 to 15 percent. As far as can be determined, there is no free silica present. Table 1 is a typical analysis of perlite ore mined in Colorado and used in the expanding furnace of the Precast Slab and Tile Co., St. Louis, Mo.

TABLE 1—ANALYSIS OF PERLITE ORE

Constituent	Percent
SiO_2	71.4
Al_2O_3	13.4
CaO	1.3
Fe_2O_3	1.7
MgO	1.0
Na_2O	2.9
K_2O	4.1
Ignition loss (H_2O)	4.2

*Received by the Institute July 28, 1949. Title No. 46-12 is a part of copyrighted JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, V. 21, No. 3, Nov. 1949, *Proceedings* V. 46. Separate prints are available at 35 cents each. **Discussion** (copies in **triplicate**) should reach the Institute not later than Mar. 1, 1950. Address 7400 Second Boulevard, Detroit 2, Mich.

†Member American Concrete Institute, Vice-President, Precast Slab and Tile Co., St. Louis, Mo.

In the manufacture of the aggregate, the graded rock is placed in a furnace which rapidly heats the particles to approximately 2100 F where the rock expands up to 10 times its original volume. At this point the particles must be rapidly moved out of the heating zone to a cooling chamber and then conveyed to the bagging or storage point. The perlite aggregate as it comes from the furnace requires no additional crushing or screening. Control, however, is essential to produce a suitable concrete aggregate.

CONCRETE AGGREGATE SPECIFICATIONS

In general, perlite concrete aggregate must weigh between 6 and 12 lb per cu ft and conform to grading requirements in A.S.T.M. Specifications C 130-42 for fine lightweight aggregate.

Aggregates weighing less than 6 lb per cu ft have been found to have too weak a cell structure for good concrete. When water is added in the concrete mix, this cell structure breaks down resulting in a low yield and a high cement content. Aggregates weighing more than 12 lb per cu ft are being produced but at a higher cost because of the low yield in cu ft per ton of perlite, and also at the expense of thermal insulation efficiency. It is the author's opinion, that if a heavier aggregate than 12 lb is desired, this should be accomplished by blending the lightweight perlite with sand or other inexpensive natural heavyweight aggregates.

Table 2 is the gradation limits of A.S.T.M. Specifications C 130-42 for fine lightweight aggregate.

TABLE 2—GRADATION LIMITS FOR FINE LIGHTWEIGHT AGGREGATE

Screen size	Percent passing
No. 4	95–100
No. 16	45–80
No. 50	10–30
No. 100	5–15

Lightweight concrete made from expanded perlites that are too fine have high shrinkage, low yield and a high cement factor. Finely graded perlite (minus 100 mesh) has a very minute cell structure. In fact, perlite of this grade has been produced weighing as low as 4 lb per cu ft. Consequently, when water is added to these fines in the mix, the cell walls of the particles collapse and the aggregate disintegrates into a comparatively heavy mush.

INSULATING CONCRETE

Perlite aggregate concrete weighs 60 to 85 percent less than normal concrete made with sand, gravel or crushed rock, but its strength in relation to density is high, as can be seen from Fig. 1.

To maintain strong insulating concretes made of perlite aggregate, the laws of water-cement ratio and aggregate gradation must be strictly adhered to. The strength of the concrete is determined, as with normal concrete, by the amount of mixing water as long as the cement paste is sufficient to fill the voids of the perlite aggregate and provides an excess proportionate to the surface of the aggregate. However, there is another fact that affects strength in lightweight concretes, particularly perlite, and that is the maximum size limit of the coarse particles. Because the aggregate particle is weaker than the cement paste which surrounds it, poor strengths are obtained with perlite using coarse aggregate of a size entirely suitable in heavy concretes; ¼-in. aggregate appears to be the maximum size for optimum strength.

Assuming that the aggregate gradation is correct and the water-cement ratio is low, the next problem with extremely light concretes is how to keep the cement paste thoroughly dispersed in the voids of the aggregate. Perlite weighs from 8 to 12 lb per cu ft, cement weighs 94 lb per cu ft, and the mixing water, 62.4 lb per cu ft. Consequently, harshness, segregation and bleeding are always prevalent in lightweight concretes, especially in the leaner mixes, unless artificial dispersing agents are introduced. It has been found that the most inexpensive way to prevent the fines from separating from the coarse aggregate particles, to prevent the concrete from bleeding, to keep the water-cement ratio

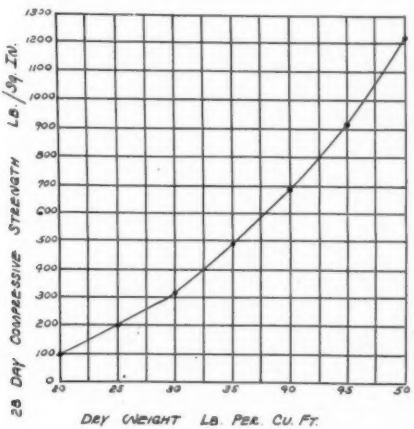


Fig. 1—Relation between strength and unit weight of insulating concrete made with perlite aggregate

TABLE 3—MIX DATA AND PROPERTIES OF INSULATING CONCRETE*

Cement content, sacks per cu yd	Water content, gal. per sack of cement	Vinsol resin, oz. per sack of cement	Dry wt., lb per cu ft	28-day compressive strength, psi	Absorption in percent water by wt., 24 hr.	Absorption in lb water per cu ft concrete, 24 hr.	Percent drying shrinkage, 7 days oven dry	Thermal conductivity, *K* factor at 75 F mean temp.
6.00	9	4	32	500	40.1	12.8	0.18	0.80
4.80	11	5	28	300	51.2	14.3	0.22	0.72
4.00	13	6	24	195	63.0	15.1	0.21	0.65
3.43	15	7	22	160	76.2	16.8	0.20	0.60
3.00	17	8	20	100	81.0	16.2	0.24	0.58

*Using 8 lb per cu ft perlite passing A.S.T.M. Specification C 130-42 for lightweight aggregate, fine grade.

low, and to give a workable mix, is to add an air-entraining agent. Neutralized vinsol resin solution has been used with satisfactory results.

The amount of agent used per sack of cement is high, much higher than that used in heavy concretes. For insulating concrete used both in poured-in-place installations and precast products the amounts recommended to be used are given in Table 3. Good results can be obtained if precautions are taken in mixing.

A good practice is to add the cement and vinsol resin solution to the water in the mixer and allow them to mix until the cement is thoroughly dispersed and frothed. The aggregate is then added to the mix and allowed to mix not more than one-half minute. If this mixing procedure is followed, no trouble in control will be experienced.

Results obtained by trying to entrain air by means of powder additions have not been too successful. In a series of tests which were not at all uniform it was found that if the air-entraining agent were added to the water, thoroughly dissolved and then added to the concrete mix, results were satisfactory, but when the powder was added to the aggregate before adding cement and water, it was difficult to obtain a homogeneous and dispersed mix in the ordinary mixing time of one minute. The resulting concrete in some cases was sound, strong and durable. In other cases there was lack of strength and serious segregation with hard and soft spots in the concrete slabs poured.

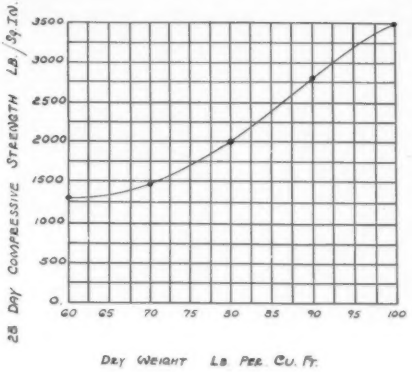


Fig. 2—Relation between strength and unit weight of structural concrete made with a mixture of perlite and sand aggregate

LIGHTWEIGHT STRUCTURAL CONCRETE

Perlite aggregate used as a blend with sand and gravel shows excellent possibilities as a lightweight structural concrete requiring compressive strengths of 2000 psi or over. In general the strength of perlite-sand concrete will follow the density-strength curve shown in Fig. 2. Comparing this curve with that shown in Fig. 1 it may be seen that the strength does not increase as rapidly with the sand-perlite blend, as is possible with all-perlite concrete.

Test results on one series of blends show that for a six sack concrete strengths will follow the above curve rather closely. The perlite and sand screen analyses are shown in Table 4. The results of the blend tests are shown in Table 5.

TABLE 4—SCREEN ANALYSIS OF PERLITE AND SAND USED IN STRUCTURAL CONCRETE

Screen	Percent passing	
	Perlite	Sand
No. 4	100	98
No. 8	94	85
No. 16	60	71
No. 30	15	50
No. 50	10	16
No. 100	5	4

CONCRETE BLOCKS

Perlite can be successfully used in the manufacture of load bearing lightweight concrete blocks by blending with sand. It can not be used successfully alone as an aggregate except for non-load bearing units

where strength of 1000 psi at 28 days is not essential. Blending makes possible the manufacture of lightweight blocks in areas where normal aggregates used in blocks are unobtainable, or are too costly. The perlite can be shipped to the block manufacturer in bags and the blending with locally purchased sand or fine aggregate can be done at the mixer.

TABLE 5—MIX DATA AND PROPERTIES OF LIGHTWEIGHT STRUCTURAL CONCRETE

Blend of aggregates by wt., percent		Unit wt. blended aggregate, lb per cu ft	Cement content, sack per yd	Vinsol resin, oz. per sack	Water content, gal.per sack	Wt., oven dry conc., lb per cu ft	28-day comp. strength, air cured in cyl., psi
Sand	Perlite						
0	100	8.0	6.22	4	9.0	33	520
75	25	26.1	5.58	1	9.5	56	1000
90	10	47.5	6.21	1	8.5	90	2200
95	5	65.5	6.01	1	7.0	102	3100
100	0	106.0	5.91	1	6.0	141	4500

CONCLUSIONS

Perlite concretes, to produce the results desired, must make use of the proper raw materials and must be put together in the proper manner. Mix control is as important with perlite as with any other concrete.

Perlite, if manufactured properly with regard to weight and gradation, can be used to make excellent insulating and lightweight concrete. Although very light, the hard glassy nature of the aggregate gives good strength with low weight. Perlite concrete can be used successfully in precast products and for structural roof slab systems both poured in place and precast. Perlite alone and perlite blended with the proper amount of heavy aggregate produce concretes of any density from 20 lb per cu ft to 140 lb per cu ft. Load bearing concrete block and brick can be produced also by blending.

Unique methods of precasting and fabrication made possible the construction of thin-walled cells for a concrete LCT comparable to one of steel.

Thin Wall Concrete Ship Construction*

By FRANCIS R. MAC LEAY†

SYNOPSIS

The development of construction methods for placing thin concrete walls is described. After several attempts using the standard method of pouring between double forms, a new method was developed which permitted the successful construction of ¾-in. and 1½-in. concrete walls. Tests were also conducted to determine the practicability as well as the strength of Gunite as a medium to unite precast units into a monolithic ship. Later these methods were used successfully in the construction of a concrete landing craft for the United States Navy.

INTRODUCTION

Many months before D-Day in Normandy, the Bureau of Yards and Docks, U. S. N., anticipating a possible steel plate storage, designed a landing craft of concrete, and called on the Corbetta Construction Co. to develop a practical method of construction. The outcome was a unique solution—combining precast sections, Guniting and poured-in-place concrete—resulting in a vessel of outstanding strength and seaworthiness.

The concrete LCT (Fig. 1) duplicated the over-all dimensions and carrying capacity of the steel LCT. The craft was 112 ft long with a 32-ft beam and weighed 224 tons. The design called for 1½-in. bulkheads, a 1⅝-in. ship bottom, 1¼-in. thick deck house walls and a 1-in. deck with 2 x 4-in. beams 6 in. on centers.

A series of tests was made to determine the most practical method of construction.

First method

The first method tried was that of pouring a cellular section 12 x 1¾ x 5½ ft with 2-in. walls, having diaphragm walls every 3 ft. All walls

*Revised manuscript received by the Institute July 10, 1949. The material in this paper was originally presented at the 42nd Annual ACI Convention in Buffalo, N. Y., Feb. 21, 1946. Title No. 46-13 is a part of copyrighted JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, V. 21, No. 3, Nov. 1949, *Proceedings* V. 46. Separate prints are available at 35 cents each. **Discussion** (copies in **triplicate**) should reach the Institute not later than Mar. 1, 1950. Address 7400 Second Boulevard, Detroit 2, Mich.

†Late Member American Concrete Institute, Chief Engineer, Corbetta Construction Co., Inc., New York, N. Y.

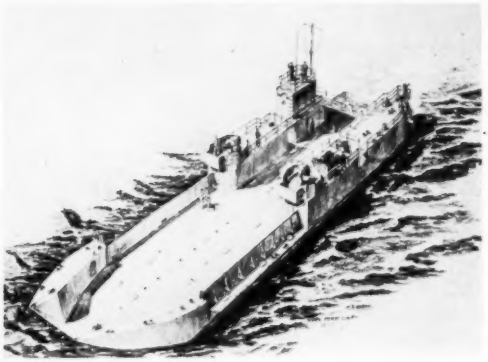


Fig. 1—Experimental concrete LCT

were reinforced with ⅜-in. bars spaced 4 in. on centers horizontally and 12 in. on centers vertically.

A concrete mix with a minimum strength of 5000 psi was used. To place the concrete in such a confined space, a very fluid mix was required. A continuous slow pour was made so as to minimize form pressures.

The plywood forms were lined with "Hydron" absorptive form liner to remove the surplus placing water and then vibrated with an internal vibrator applied to the exterior of the forms.

The method was a failure, leaving an opening in the wall about 2 x 3 ft. Many other places which appeared perfect upon removal of the forms proved to be only thin skins of concrete covering an air space.

It was concluded that failure was caused by placing too slowly, the friction of the absorptive form lining, and the fact that absorption removed the water from the concrete in the confined areas, causing dams which prevented the concrete from flowing into place.

Second method

It was then decided to go to the other extreme using forms lined with linoleum. The concrete was mixed in advance and a funnel was erected on top of the forms permitting rapid placement.

The fast placing developed a full hydrostatic head which together with impact caused failure.

Third method

The third attempt repeated the second method, but with the forms greatly reinforced. This concrete cell was free from honeycombing but the wales deflected badly leaving the walls thicker than the specified 1½ in.

It was concluded that the placing of thin concrete walls between double forms was not practical. Without through ties the formwork

would have to be massive to overcome any deflection which would increase the thickness of the walls and the weight of the ship.

ROTATING FORMS

It was decided that the only satisfactory way to obtain thin concrete cells was to cast in a horizontal plane. This led to the manufacture of open end cells or tubes which were cast on a rotating form. The forms were boxes braced against a center shaft. Concrete was placed horizontally, finished, covered and then the box was turned 90 degrees and the next side placed.

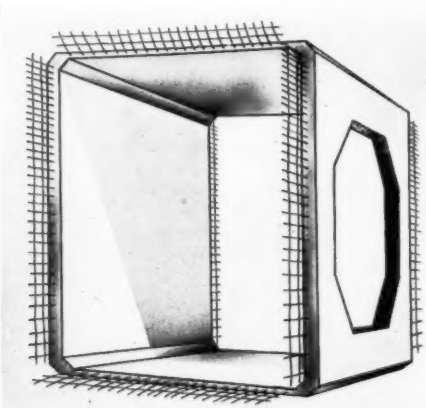


Fig. 2—The cells were 4 x 7 x 5 ft. The 4-ft sides were ¾ in. thick and the 7-ft sides were 1½ in. thick with dowel wire projecting at the four corners and both ends. A welded wire mesh was used for reinforcing the cell. The concrete, which tested 8500 psi at 28 days, was proportioned 94 lb cement to 130 lb sand to 125 lb of ¼-in. grits.

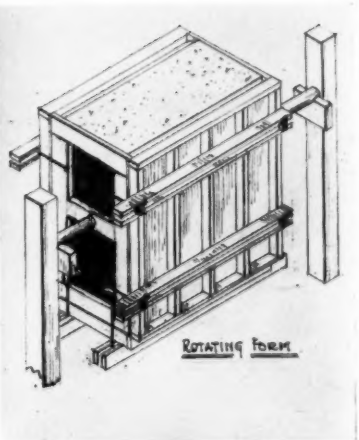


Fig. 3—The rotating form was a simple apparatus comprised of a knock-down inner form and a removable outer form whereby a thin wall could be poured in a horizontal position. The inner forms and ends were erected on a pipe shaft. Around the inner form the reinforcing mesh was wrapped, leaving the ends of the mesh projecting through the forms for dowelling to adjacent units. This eliminated the difficulties of pouring in a vertical position and at the same time permitted the inspection of the concrete and steel at the time of placing.

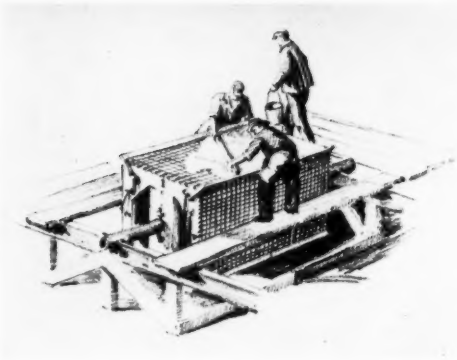


Fig. 4—A well mixed, low slump concrete was placed on one face of the cell in a horizontal "table top" position and screeded to the specified $\frac{3}{4}$ in. or $1\frac{1}{2}$ in. thickness.

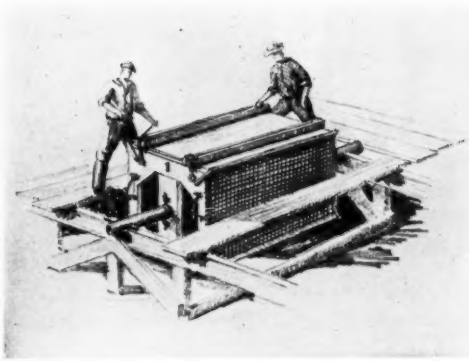


Fig. 5 — Following the screeding, an over-all exterior form was clamped over this finished face.

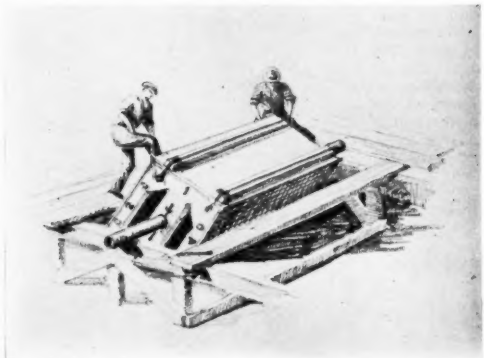


Fig. 6—The form was then rotated bringing the next side into a horizontal position for the second pour.

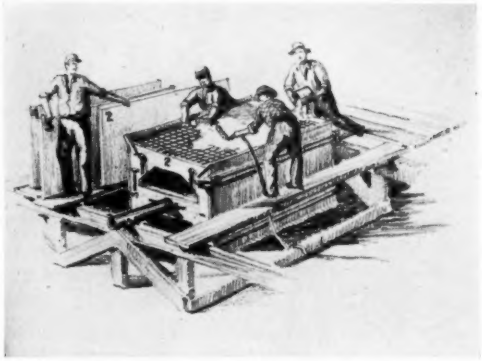


Fig. 7—The operation of placing, screeding and clamping on the exterior form was followed for each of the four sides of the box. The edges of each side were arranged in abutting positions so that they merged and were bonded together to form a monolithic cell.

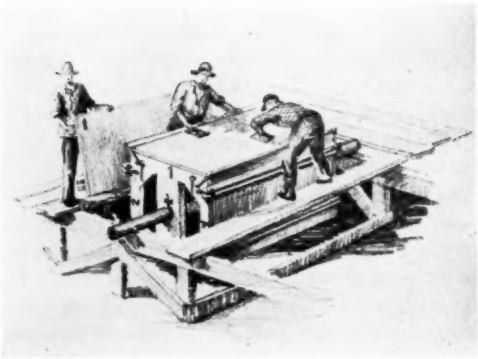


Fig. 8—The first cells cast by this method were failures due to top surface imperfections caused by entrapped air or water. In some cases, indentations were 1½ in. in diameter and carried through the walls. To prevent this and to secure a structurally sound cell, it was necessary to again rotate the box after casting and before the concrete had set, removing each outer form, steel troweling the surface and replacing the form, thereby eliminating accumulated air or water bubbles and correcting surface defects.

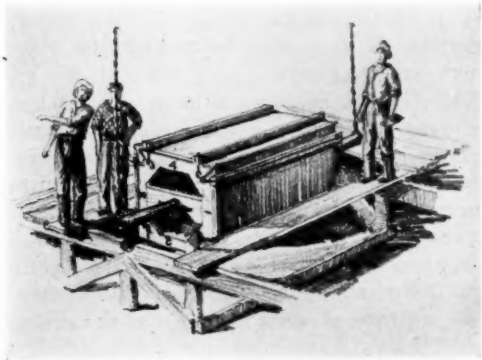


Fig. 9—Upon completion of the troweling of the fourth side of the cell, overhead cranes moved the box to the curing area.

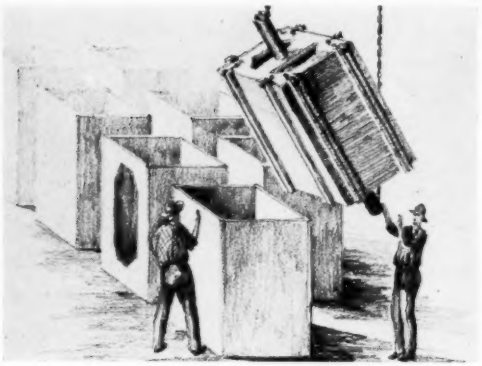


Fig. 10 — The following day the forms were removed and the cell cured under a continuous water spray.

WELDING CONCRETE

It was decided that it would be necessary to use pneumatically applied concrete to weld the cells and precast slabs together and to achieve a watertight hull. Tests were made on precast slabs 1½ in. thick with mesh placed on the neutral axis in casting and on ¾-in. slabs over which mesh was laid and then the slab built up to 1½ in. by application of Gunite.

In placing the Gunite, Kraft paper, fine wire mesh, wire lath and ⅜-in. plywood were tried as back-up forms. Plywood proved to be the best backing as it was necessary to have a wall of uniform thickness and true alignment.

At the time of the experiment plywood was critically scarce and, to eliminate the necessity for its use, the scheme of making the back-up wall a permanent part of the structural member was evolved using a ¾-in. precast slab over which mesh was applied and an additional ¾ in. of Gunite was shot on. This scheme had the additional advantage of eliminating the necessity for removing the back-up forms from confined places.

It was then necessary to determine whether the laminated sections of concrete and Gunite would act as a monolithic section when under stress. Thirty specimens were prepared for bending, compression, shear and torsion tests. Specimens were of precast homogeneous concrete sections, precast sections with Gunite lamination and beams in which Gunite was used as a welding material.

On the day following the precasting operations, mesh was laid over the face of each ¾-in. slab and ¾ in. of Gunite applied. The Gunite mix consisted of one part cement to three parts of silica sand with some small grits. Water content was determined visually to give the driest

material that would adhere. Gunite was placed while the slab was still relatively green.

BREAKING TESTS

Slabs

The precast slabs were made with a high-early strength portland cement and tested 6000 psi at 28 days.

Slabs 1 and 2 were homogeneous precast concrete 1½ in. thick. Slabs 10 and 11 were ¾ in. precast concrete and ¾ in. Gunite, tested with the Gunite on the bottom. Under test, with load at the center of a 42-in. span, breaking in each case occurred in direct flexural failure of the slab. Inspection of the fracture showed no tendency of the Gunite to spall or separate from the concrete.

It also was noted that the tension cracks on the edge of the laminated slab progressed steadily through the Gunite and the concrete in the same manner as in the homogeneous slab. Although the laminated slabs showed greater strength than the homogeneous slabs it was believed to indicate only that the reinforcing mesh was in a more advantageous location. Table 1 summarizes the tests.

Homogeneous slab No. 3 with 1½ in. precast concrete, slab No. 12 with ¾ in. of Gunite on top of ¾ in. of concrete, and slab No. 13 with ¾ in. of Gunite on the under side of the concrete were tested with loads applied on the quarter points. This permitted a greater concentraton of loads on the specimens due to the reduced bending moment, but failures were in flexure as before.

Inspection of the slab fracture showed no tendency of the Gunite to spall or separate at the junction of the concrete and the Gunite. The larger extreme fiber stress on slab No. 13 was believed to be due only to the mesh being in a more favorable location in the slab.

Beams

Beam specimens were cast with no reinforcing; beams No. 25 and 28 were homogeneous concrete; No. 26 and 27 were cast in two pieces and connected by a Gunite weld; No. 29 had Gunite laminations both top and bottom, and No. 30 was a combination of welding and laminations. Testing to destruction produced no tendency to spall or separate the Gunite from the concrete. In all Gunite welded beam specimens the failure in extreme fiber was through the concrete and not through the Gunite. The fact that beam No. 25 failed at twice the tension stress of beams No. 26 and 27 would seem to indicate that the homogeneous beam was stronger than the welded beam. However, it should be noted that the failure in tension was through the concrete and that the laminated beam No. 29 showed about the same tension value as the homogeneous beam.

Columns

Six of the 4-ft. slabs were tested in compression as 4-ft. columns. Three of the slabs, No. 4, 5 and 6, were homogeneous concrete. Two of these failed by crushing at the base while the third failed by bending at midpoint.

Slabs No. 14, 15 and 16, made up of ¾ in. precast concrete and ¾ in. Gunite, failed by bending at the midpoint.

The homogeneous slabs indicated a higher value in compression than the slabs made of laminations but there was no indication of failure of the two materials to work together. Again the Gunite showed no tendency to spall or separate from the concrete.

PUNCHING TEST

A punching shear test was performed on slab No. 20, in which the slab was supported from below on four blocks spaced 36 in. center to center around a point where the load was applied through a steel plate 3⅝ in. square.

This spacing was selected to give only a minimum of support for the Gunite. The test on slab No. 20 contributed no information as the slab failed in tension before punching.

In testing slab No. 23, however, the spacing of the blocks was reduced to 18 in. center to center and a cleanly punched hole resulted. This test was made with the Gunite lamination on the bottom, permitting every opportunity for the air applied mortar to separate from the concrete. Even here the Gunite showed no tendency to spall or separate from the precast concrete.

TORSION TESTS

Not satisfied with the compression and tension tests alone to bring out the bending characteristics of Gunite, an apparatus was devised to subject the 12-in. x 1½-in. x 4-ft slabs to a torsion test. Slab 9 was a homogeneous slab and slabs 17 and 18 were laminated. The bending moment at failure for slab 9 was 4704 in.-lb, while the two laminated slabs reached 5280 in.-lb.

Bending moment computed from the readings obtained in the test indicated a shear stress of 785 psi for the homogeneous slabs and 875 psi for the laminated slabs. In the torsion tests as in the other tests, the Gunite showed no tendency to spall or separate from the concrete.

TEST CONCLUSIONS

All evidence derived from the tests indicated that it was possible to construct structural members of Gunite and concrete which act as a monolithic unit under load and produce equivalent strength. The test results also indicated definitely that it was possible to satisfactorily weld, by Gunite, precast concrete members for use in any construction.

TABLE I—SUMMARY OF TESTS ON HOMOGENEOUS AND LAMINATED SLABS

Test No.	Description	Age, days	Load, lb		Fiber stress, psi	
			Crack	Failure	Crack	Failure
	Beam test—1½ x 12 x 42 in.—center load					
1	Concrete	11	115	318	134	370
2	Concrete	11	220	408	257	475
10	Concrete + Gunite (Gunite in tension)	11	336	620	395	730
11	Concrete + Gunite (Gunite in tension)	11	265	1000	310	1267
	Beam test—1½ x 12 x 42 in.—load at quarter points					
3	Concrete	11	430	1335	502	1560
12	Concrete + Gunite (Gunite in compression)	11	590	850	690	1000
13	Concrete + Gunite (Gunite in tension)	11	1070	1760	1240	2050
	Beam test—4 x 6 x 42 in.—load at quarter points					
25	Concrete	5	1520	1520	322	322
26	Concrete + Gunite (Gunite weld in center)	11	750	750	160	160
27	Concrete + Gunite (Gunite weld in center)	11	685	685	150	150
	Beam test—6 x 6 x 42 in.—load at quarter points					
28	Concrete	5	2460	2460	336	336
29	Concrete + Gunite (1 in. Gunite top and bottom)	11	2400	2400	313	313
	Beam test—6 x 8 x 42 in.—load at quarter points					
30	Concrete + Gunite (Gunite weld in center)	11	3480	3480	231	231
	Punching shear stress—1½ in. x 4½ ft x 5½ ft				Shearing stress	
20	Concrete—failure by tension	16	—	1500	—	—
23	Concrete + Gunite (Gunite on bottom)	16	—	8450	388	388
	Column test—1½ in. x 1 ft x 4 ft			Max. load	Max. compressive stress	
4	Concrete	16		93,400		5129
5	Concrete	16		99,000		5500
6	Concrete	16		130,000		7250
14	Concrete + Gunite	17		80,800		4344
15	Concrete + Gunite	17		89,800		4926
16	Concrete + Gunite	17		93,800		4919

SHIP CONSTRUCTION

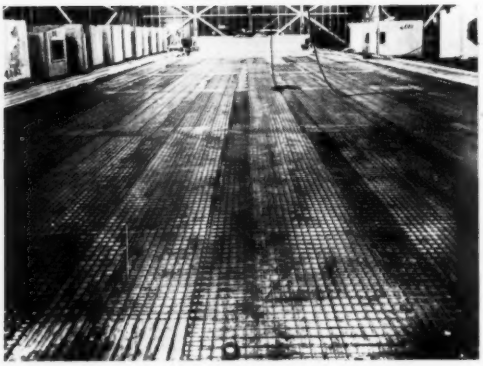


Fig. 11—The form for the ship bottom was a carefully leveled slab of concrete laid between the shipways on the ground and covered with plywood nailed to sleepers placed in the concrete. Welded wire mesh reinforcing for the ship bottom was then placed, using 2 x 2 in. No. 3 and No. 8 wire on the bottom layer and 2 x 2 in. No. 3 and No. 4 wire for the top layer, separated by ¼-in. round bars at 12 in. on centers.

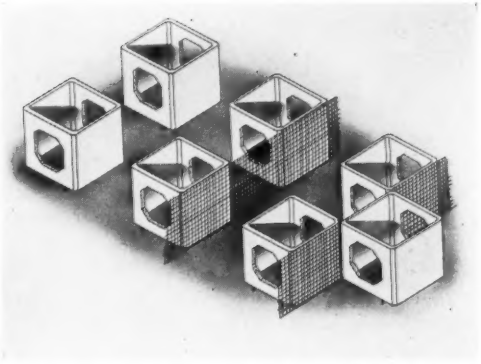


Fig. 12—Following the placing of the mesh, the precast cells, each supported on four adjustable cone nut chairs, were placed in a checkerboard pattern on the ship bottom.

Between the boxes at hull sides, ¾-in. precast slabs were inserted. The slabs were reinforced with 2 x 2 in. No. 8 wire mesh, the ends of the wires projecting as dowels on the four edges. Each slab was supported on two cone nut chairs.

An additional sheet of the same wire mesh was placed over the outside of the boxes and slabs for the entire length of the hull side and between the boxes on each longitudinal bulkhead line.

Low slump concrete for the ship bottom (1⅝ in. thick) was placed in one continuous pour from stern to bow engaging the bottoms of the boxes, slabs and sheets of mesh.

Fig. 13—Forty-eight hours after casting the ship bottom, ¾ in. of pneumatically applied concrete was placed on the outside of the hull and the 4-ft sides of the boxes.

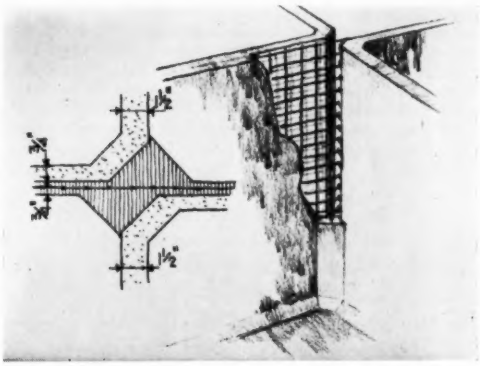


Fig. 14—The pneumatically applied concrete engaged the continuous sheets of mesh, building up the longitudinal bulkheads and hull sides to the required 1½ in. thickness. The pneumatically placed concrete when placed upon the ¾ in. precast concrete made a composite member of the two materials. The sides of the hull were then steel troweled to a plate glass finish.

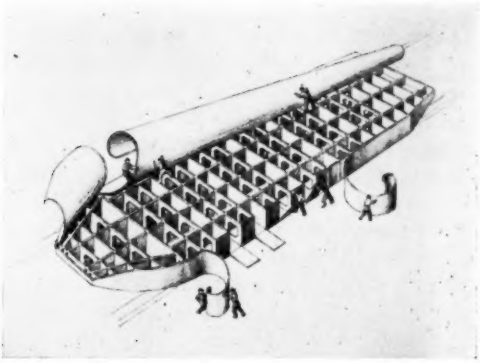


Fig. 15—With the deck slab and the pneumatically placed sides peeled back, the hull is seen to consist of a set of precast slabs and cubes.

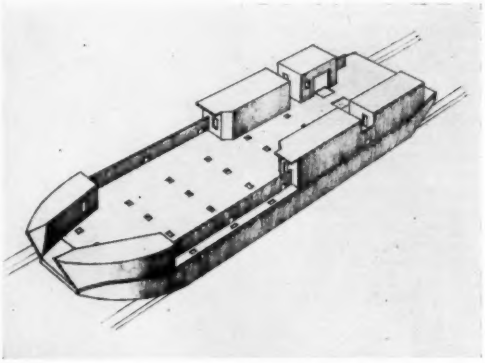


Fig. 16—The deck consisted of a 1-in. slab with 2 x 4 in. beams, 6 in. on centers, except for the deck house floors which were flat slabs 1¼ in. thick. The deck beams were reinforced with one 5/8-in. round bar on top and one 3/8-in. bar on the bottom. Over each longitudinal bulkhead two ¾-in. bars and one ⅞-in. bar were placed. The slab was reinforced with 2 x 2 in. No. 8 wire mesh.

Six deck houses (forecastle, foreward and aft on both port and starboard sides) were constructed of precast slabs 1¼ in. thick having pilasters 6 in. wide and 7¼ in. deep, 4 ft on centers and reinforced with No. 8 wire mesh for the walls and four ¾-in. rods in each pilaster. They were cast with the rods and the mesh projecting top and bottom for dowels. Outside sections of the two forecastles were precast in monolithic concave and convex curves measuring about 15 ft.

Following the placing of the deck reinforcing, the deck house wall slabs were placed in position and then a continuous pour was made for the deck, engaging the tops and dowels of the bulkheads as well as the bottom dowels of the deck house slabs.

All joints of the deck house wall slabs were closed with pneumatically applied concrete and the deck house roofs were poured in place completing the concrete work on the ship.

CONCLUSION

How well did this concrete LCT stand up? Well, she outrode a hurricane, made landings on gravel strewn beaches and mudpockets and was driven full speed ahead onto hard and soft beaches under simulated war time conditions. After 1½ months of the toughest kind of tests, the navy hauled the ship onto a marine railway expecting to find the bottom worn down to the appearance of terrazzo, but the concrete was unscathed—the original form marks were still visible.

Economically, the cost of concrete barges compares favorably with steel vessels of the same type and as assembled under war time conditions.

ORGANIZATION

The ship was designed by A. Amirikian, Principal Engineer, U. S. N. Officer in charge of construction was Lt. John Erickson, U. S. N. The construction was carried out by the Corbetta Construction Co. under the direction of the writer and assisted by Charles Prokop, James Lyttle, Robert Sanderson and Henry O'Byrne.

The author puts his finger on a number of points in specification writing that are productive of absurdities and unworkable conditions.

Specifications Should Be Realistic*

By HARRY F. THOMSON†

SYNOPSIS

Specifications for concrete in moderate-sized and lesser construction frequently contain provisions which are ambiguous, conflicting in application, or do not fully recognize local materials. Most of these questionable features result from (1) inadequate understanding of the characteristics of concrete, or (2) use of ready-written specifications without revision for conditions or changes in standard requirements.

Among the features discussed are: specifying both method and result; "frozen" specifications; habitual use of "1-2-4"; multiple provisions for quality; strength without naming consistency; recognition of local materials; use of compression tests; time of placing; bin-test of cement. Numerous quotations from specifications are given, and suggestions offered for bringing the provisions in line with actual conditions.

INTRODUCTION

Due to the very nature of concrete, a specification writer may consider that drawing a specification for the material to be used on commercial construction is a chore which never becomes an entirely satisfactory accomplishment. The inability to check on the actual, final characteristics of concrete prior to or at the time of incorporation in a structure differentiates it from most building materials. During recent years there has been notable improvement in the "average quality" of specifications from both public and private sources; such agencies as the A.A.S.H.O., the Federal Specification Board, the Bureau of Yards and Docks, the Corps of Engineers and others have developed specifications with many excellent features based upon wide experience under various conditions and requirements. A broad influence has been exerted by the Bureau of Public Roads' review of state highway department specifications, which in turn have influenced other local specifications, including those of county, city, school board, and private engineers.

*Received by the Institute Aug. 25, 1949. Title No. 46-14 is a part of copyrighted JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, V. 21, No. 3, Nov. 1949, *Proceedings* V. 46, Separate prints are available at 35 cents each. **Discussion** (copies in **triplicate**) should reach the Institute not later than Mar. 1, 1950. Address 7400 Second Boulevard, Detroit 2, Mich.

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But in spite of so much available guide material, there is still room for improvement in the details of specifications applying to local construction, especially the moderate size and smaller projects. Many private engineers and architects could render better service to their clients if they revamped their concrete specifications by taking advantage of the modern "type" specifications available from such sources as ACI, A.S.T.M., F.S.B. and others. In general, a well-drawn specification, based on a knowledge of the materials available, the characteristics of concrete and the results desired in the construction, will avoid misunderstandings and will result in better concrete at moderate cost than if the specification is poorly drawn and ambiguous.

SPECIFICATION FEATURES

With a view to stimulating interest in further general improvement in specifications for concrete, the following discussion analyzes a number of dubious features in specifications which have come to the attention of the writer and offers suggestions for making some of these provisions more realistic of the applicable conditions.

Specifying both method and results

In view of the presumably simple nature of a concrete mix and the fact that the wet concrete to be inspected is preliminary to the final hardened concrete in the structure, many specification writers attempt to decree both the method of production and the characteristics of the final material. Such dual provisions might be quite satisfactory if the two requirements, *i.e.*, method and results, are consistent with each other, but that presumes a technical knowledge of concrete in all its phases which is seldom available. Too frequently the requirements as to method and results are conflicting, even to the point of uncertainty as to which should actually govern.

The old adage "a little knowledge is dangerous" is frequently evidenced by specifications for concrete. If some of the provisions which are set forth were followed literally, increased expense and sometimes weaker structures might result—exactly opposite to what the specifier expected. Typical of such a specification was one for a large hospital, which read:

> All concrete shall be proportioned as follows:
>
> | | |
> |---|---|
> | Proportions by volume, dry rodded materials | 1:2.0:4.0 |
> | Amount of water (gal. per sack) | 8.5 |
> | Strength required (psi) | 2000 |

It was not stated that the 8.5 gal. of water was maximum, but elsewhere it was specified that the slump should not exceed 5 in. Actually, with the well-graded aggregates which were available, a 1-2-4 concrete

with 5 in. slump would develop approximately 3000 lb in 28 days. When this was pointed out to the specifier, he authorized revision of the proportions to produce a 2400 lb strength, which was of course a cheaper concrete than the original, but had the authorized 8.5 gal. of water been used the strength would have been less than the 2000 lb used in the structural design.

As indicating a confused understanding of terms, this specification contained the following additional provisions—

"All proportions of quantities will be calculated from Abrams' curves to secure the predetermined strength. . . . All fine aggregates must be measured by weight. If concrete is proportioned at the site, the fine aggregate must be measured in a condition of complete saturation, and coarse aggregate may be measured by either volume or weight. . . . If the concrete materials are delivered from a central batching or mixing plant, all materials shall be measured by weight. . . . The fineness modulus of aggregates will be determined by test and the mix calculated on the basis of dry rodded materials." (Fineness modulus was not mentioned elsewhere.)

This specifier apparently had a conglomeration of ideas regarding water-cement ratio, inundation and fineness modulus, without a clear understanding of the significance of each term. Similar confusion occurs in many specifications.

"Frozen" specifications

Another all too common practice is to use a pet frozen specification for buildings in all parts of the country, regardless of the characteristics of materials available locally. Thus the proportions which yield specific results where crushed stone and coarse sand are available would yield a very different final concrete if used in a locality having only gravel and fine sand available as aggregates. It appears reasonable to expect that a specification writer should inform himself regarding local materials and practices and base the specification accordingly.

A recent example of the illogical results from the application of dogmatic ideas occurred in the simultaneous construction of projects located only one mile apart for two government agencies. The same firm of architects-engineers designed and wrote specifications for both projects. But the standard requirements of each government agency regarding coarse aggregates were applied to the respective projects; one specified 1½ in. maximum size of aggregate and the other 1¼ in. The result was that the concrete producer who served both projects could not use the same supply of coarse aggregate on each and had to furnish the concrete from two separate plants. When the illogical situation was pointed out to the respective agencies, the answer was that the terms of the specifications must be met and the extra expense involved must be accepted. No question was raised that either aggregate would not produce satisfactory concrete for either project.

UNREALISTIC SPECIFICATION PROVISIONS

A number of instances of unrealism in specification provisions are cited and discussed in the following remarks. The list is by no means complete, but may serve to indicate some of the "bugs" which could be eliminated by reasonable knowledge of and attention to the details involved.

1-2-4 mix

This most common specification for the quality of concrete in building work is an inheritance from the early use of portland cement concrete in the northeast section of the country. It was probably a reasonable provision when materials were measured only by shovels and wheelbarrows and before the principles of mix design with given materials were understood. But in most parts of the country a mix of 1-2-4 proportions does not yield a good, workable concrete; with commercial aggregates in many localities, an actual 1-2-4 concrete is undersanded and harsh. If a specification writer really wishes to indicate the desired quality by volume proportions, he should inform himself as to the proportions in which available materials should be mixed to yield the quality of concrete he wants.

A short time ago the contractor on an important industrial project called in the concrete laboratory of a nearby university to design a mix using the available aggregates; the recommended design represented proportions of substantially 1-2½-3½; the concrete was very workable and the strengths were satisfactory. When about half of the job had been placed, a new inspector asked for details of the proportions being used; when informed, he ordered that only 1-2-4 should be used as provided in the specifications. As no argument could change this decision, the job was finished with a concrete which did not place as well and developed a poorer surface and lower strengths than the preceding mix. Such an attitude reflects limited information and appears unreasonably dogmatic.

It might be remarked that the blasé confidence of many specification writers that merely stating "1-2-4" in the specification will insure good concrete in the structure is downright pathetic. Too frequently the concrete mixer is permitted to interpret "1-2-4" as he wishes and to furnish such quality as he sees fit; no effort is made to check on the proportions used, even by the simple expedient of counting the sacks of cement used in a day's pour. Often the contractor's conscience is the only guide and the owner may or may not receive the quality he is presumably paying for. We have even known instances where "1-2-4" was interpreted as "one bag of cement to two wheelbarrows of sand and four wheelbarrows of gravel" and the concrete man insisted he had

complied with the specification. The supervision of proportioning is too frequently inadequate, and this leads to unfairness toward competition based on using the quantities actually specified.

Single coarse aggregate

In many areas more than a single material is available for coarse aggregate, such as gravel, crushed limestone, crushed slag, etc. In such localities it is customary to specify that only a single material may be used as coarse aggregate. However, as the gravel may run to the smaller sizes with a premium on the larger, and the crushed stone may have a preponderance of larger sizes with a deficiency of the smaller, the really conservative and economical practice would be to use a blend of such gravel and stone (assuming that each is durable under the conditions of the structure) and thereby obtain a better grading and a denser and more workable concrete at less cost than if either aggregate were used alone.

An interesting instance of beneficiation of the concrete through blending of coarse aggregates was reported in a paper by Scholer and Gibson* which reported improvement in the performance of certain highway concrete, in service and by test, by the addition of 25 to 40 percent of stone aggregate to the sand-gravel used previously. Although the objective reported in that paper was control of the alkali-reactivity problem, the recommendation of blending coarse aggregates indicates the feasibility of such practice when economic considerations warrant. The growing use of 2 sizes of coarse aggregates also suggests the possibility of 2 materials, if not prevented by the specification. The current discussion of incompatibility of coarse and fine aggregates of different origins in hydraulic structures is pointed toward a problem quite distant from the writing of specifications.

Multiple provisions for quality

The common practice of many specification writers to stipulate the quality of concrete by several provisions, which are frequently conflicting and inconsistent, leads only to confusion as to what is really expected. The standard specifications by a certain trunk line railroad have until recently included a table showing the requirements for each of several classes of concrete as regards (1) proportions, (2) cement content, (3) water-cement ratio, (4) maximum water content and (5) strength at 28 days, and the five provisions were not consistent with each other for the materials available at a given job-site. Such multiplicity indicates a lack of understanding of the design of a concrete mix. As a given concrete can have only a single cement factor, any other provision which implies or requires some other factor causes uncertainty and conflict.

*Scholer, C. H. and Gibson, W. E., "Effect of Various Coarse Aggregates Upon the Cement-Aggregate Reaction," ACI JOURNAL, June 1948, *Proc.* V. 44, p. 1009.

Sometimes there may appear only two or three of these conflicting provisions, but the confusion still exists. Thus the description of concrete may refer to a "nominal 1-2-4 mix," which might indicate 5⅓ sacks of cement per yd for local materials, but this same paragraph may state several lines further that the concrete must contain at least 6 sacks of cement per yd. A contractor who contemplates furnishing 1-2-4 and bases his price accordingly would not be complying with the 6 sacks per yd requirement, which really refers to a better quality of concrete. For the sake of accuracy and definiteness only one of these provisions should be stated.

Various examples could be quoted. One specification for an industrial plant stated—

Type of concrete:

28-day strength	7-day strength	Maximum water per sack cement	Minimum cement per cu yd
2500 psi	1700 psi	6¾ gal.	5.0 sacks

Further in the same specification it was stated—

The following slumps . . . shall not be exceeded:

Parts of structure	Slump, in.	
	Maximum	Minimum
Heavy wall, slabs, beams, footings	6	3
Thin walls and columns	7	4
Pavements	3	1

The maximum water specified would not produce as wet a concrete as required for the thin walls.

Another specification read:

"Mix shall be 1:2:4; one part cement, two parts sand, and four parts stone or gravel. One to 6 ratio of cement to total aggregates by volume measured dry. Water-cement ratio not more than 6½ gal. per sack of cement including surface water."

In this case the 1-2-4 proportion is an adequate provision if those are the proportions actually desired; inclusion of "1 to 6 ratio" is superfluous and as worded is indeterminate.

Strength without naming consistency

Frequently a requirement as to strength is named but without indicating the accompanying slump or other measure of consistency. A concrete developing 3000 lb with 1-in. slump will contain less cement than a concrete with 6-in. slump designed for the same strength. But the

1-in. slump may be unsuitable for the type of construction proposed. Hence the expected slump, or other measure of consistency, should be stated definitely so that the proper quality only will be figured.

The specification of a large city intended to cover a range of municipal construction read—

Each class of concrete shall develop a compressive strength not less than the minimum shown in the following table:

Class	Proportions	Min. sacks cement per yd	Max. W/C ratio, gal. per sack	Min. 28-day strength, psi
A	1:5	6.7	6	3000
B	1:6	6	6½	2500
C	1:7	5	7	2200
D	1:8	4½	7½	1200

These water-cement ratios are the maximum permissible.

As the provisions in this table would permit a very wet concrete in Classes A and B, there should have been an indication of maximum slump for each class to insure a consistency well adapted to the respective work.

The use of a "strength specification" for indicating the desired quality of concrete is growing in popularity. This practice represents the economical method of purchasing concrete as it permits the producer to use his materials in the most effective manner to produce the specified quality of concrete. The desired consistency should be an accompanying provision as indicating quality. But this type of specification should be recognized for what it is, namely a requirement for a named end-product to be obtained. It is to be presumed that any contractor undertaking to produce such an end-product must be reliable and technically qualified to properly handle the materials to accomplish the specified result.

Water-cement ratio

In spite of the extensive publicity attending the introduction of this factor as an item of specifications, its significance is still much misunderstood. Many specification writers who have seen the term in the literature have attempted to include it in their specifications with little appreciation of the physical characteristics involved. Rather than attempting to specify "water-cement ratio" it would usually be simpler and more easily understood to name the maximum gal. of water per sack of cement. And of course some other factor must be named, such as cement content, to indicate fully the quality of concrete desired.

A sad commentary on the present lack of understanding is found in the presumption by many specification writers that the mere act of

including a reference to water-cement ratio immediately and *per se* endows the concrete with some magic, superior quality, which it would not have if the term were not used. Ability to insert the term is sometimes considered very clever, whether it reflects the facts of a good mix or not. It is sometimes remarked that "this is water-cement ratio concrete, and therefore has superior quality;" such a comment fails to realize that all concrete has a water-cement ratio but that until recently nobody noted the values to permit its determination. The insertion in an already adequate specification of a clause such as "This concrete shall be controlled by the water-cement ratio" adds nothing of value to the provisions. There is need for further enlightenment of many writers as to the significance of the water-cement ratio factor.

Water content

In attempting to give the water content, many specifications are drawn carelessly, in that it is not stated whether the quantity named is total water or added water. Such omission could be confusing and serious. Unless the writer knows exactly the moisture in the aggregates, the water content should be specified as "total," with provision that the free moisture in the aggregates be deducted to arrive at the amount of "added" water for the mix.

Maximum size aggregate

It is misleading to specify a maximum size of aggregate as 1½ in. when actually a 1-in. size is desired. The common provision for 1½-in. size apparently grew up in limestone areas and is intended to mean that the stone shall be crushed to at least 1½-in. size. But in localities having gravel aggregate just the reverse conditions apply, in that the 1-in. size suitable for structural work is readily available; but the 1½-in. size, which is really not suitable but appears indicated by the specification, commands a premium in price. The specification should name the top size which is actually desired. Also, there should be a clear indication as to whether round or square openings are to be used in making sieve determinations, although the trend is toward the general use of square screens.

In the specification for an important industrial project, the provision for coarse aggregate read—"Coarse aggregate shall consist of crushed stone or gravel and shall conform to A.S.T.M. Standard Specification C 33-46." Such wording is inadequate as there is no indication of the size of aggregate required.

Combined sizes of aggregates

A poor practice in indicating mix proportions occurs when the expression "1 to 6" is used as indicating 1-2-4 or "1 to 8" as indicating 1-3-5. If it is really intended that the mix shall comprise 1 cu ft of cement

to 6 cu ft of combined aggregates, then the expression is used properly. Too frequently the specification writer names "1 to 6" as a short-cut reference to 1-2-4 or 1-2½-3½ as the desired proportions. Such a writer fails to understand that the cement content of a cu yd of 1-6 of combined aggregate might be materially less than the content of an actual 1-2-4 mix.

The following provision in the paving specification for a moderate sized city is ambiguous—"The ratio of cement to the dry volume of the fine and coarse aggregate shall not exceed 1 to 4½." The volume of the combined aggregates is probably intended, but occasionally a similar wording is used with the intent that the proportion of aggregates is the "sum of coarse and fine aggregates, measured separately."

In the specification for another city appears the three following provisions—

"The concrete shall be proportioned one sack of portland cement, 4.5 cu ft of fine aggregate, and 5.3 cu ft of coarse aggregate . . . . The real mix from which the field proportions above mentioned are to be determined shall be 1 sack of cement to 5.85 parts total aggregate measured after mixing and when in a rodded and compacted condition . . . a cubic yard of concrete in place shall contain not less than 4½ sacks of cement."

In this case the proportion of 1-5.85 is adequately described, but whether it conforms to the provisions of separate aggregate proportions and the cement content might be questioned.

The object in referring to "combined aggregates" appears to be recognition of some variance of the ratio of fines to coarse to obtain a workable mix, but there is need of indicating how the aggregate proportion is to be determined.

Recognize local materials

Sometimes a writer who has developed a good specification based on the materials in a given locality will use the same specification in a distant locality, regardless of whether materials of the same characteristics are readily available. If the materials should differ as to size, grading, voids, etc., then the concrete specification should be revised as may be indicated. A satisfactory specification with crushed stone aggregate may not be equally satisfactory with gravel aggregate, although with proper adjustments an equally satisfactory concrete may be mixed with each.

In some areas in the Middle West the only coarse aggregate is gravel with a top size of about ½ in. If a specification requiring a coarse aggregate with 10 percent retained on a 1½-in. mesh were applied in such an area, there would result either no bid complying with the specification or a very high cost to cover the expense of shipping from a distance an aggregate containing the larger size specified. On the other

hand, a concrete suitable for the purpose could probably be obtained by using the local coarse aggregate and adjusting the cement content.

Some of the trunk line railroads have a problem in this respect as the nearby aggregates along the system may vary widely in characteristics and therefore may not produce equally good concrete if used under a system-wide and inflexible specification. Possibly a table summarizing the characteristics of the respective aggregate supplies and indicating corresponding quantities and cement contents to be used should be included in the basic specification for widely scattered construction projects.

Use of compression tests

The purpose for which compression tests are to be used is frequently not stated clearly. One or both of two purposes for making test cylinders usually apply: (1) to check the quality of concrete used, and/or (2) to check the development of strength in the structure. For checking the quality the cylinders should be tested under current A.S.T.M. standard procedure. The curing of the cylinders has no relation to the exposure of the structure in which the concrete is used and the test results should be so considered. But if cylinders are used to check on the probable development of strength in the structure, then such cylinders may be required to have the same exposure as the structure; however, the results from these cylinders should not be interpreted as giving any indication of the quality of the concrete. These two functional objectives of taking cylinders should be recognized clearly in the specifications.

The specification for a large industrial plant provided—

"All concrete test cylinders shall be prepared, tested, etc. in accordance with A.S.T.M. Specifications, Designation C 31-35. The specimens shall remain on the job not longer than 48 hours protected from any form of abuse and stored under temperature and atmospheric conditions identical to the concrete in the structure and then (at the end of 48 hours) to be delivered to or obtained by the Testing Laboratory."

At another point this same specification stated—

"All concrete shall have an ultimate strength of not less than 2800 psi when 28 days old. If high-early-strength cement is used, the concrete shall have a compressive strength of not less than 2000 psi in 24 hours and not less than 4300 psi in 28 days."

Under these provisions the contractor and the ready-mix concrete producer would be required to guarantee strengths of cylinders experiencing job conditions for the first 48 hours, which strengths probably would not be indicative of the quality of the concrete as delivered. Another inconsistency was a requirement for 24-hour strength with high-early-strength cement, although cylinders were not to be removed from the job for 48 hours. Incidentally, this specification was issued for a project in the middle 40's, several years after the A.S.T.M. standard had been revised to provide for removing specimens to the laboratory

at the end of 24 hours to permit testing high-early-strength concrete for 24 hour strength.

Current A.S.T.M. specifications

It is frequently noted that reference is made to A.S.T.M. or other standard specifications which are obsolete, or provisions are stated which have been revised in the current document of standards. (The circumstances mentioned in the preceding paragraph are typical.) Such errors apparently result from failure to keep an office specification revised to date as changes are made in the A.S.T.M. provisions. Some specifications still provide that test cylinders are to be removed to the laboratory moist room within 48 hours, whereas this provision was changed to 24 hours several years ago. This detail in procedure may not be of great importance for tests at 28 days, but it is important for 3- or 7-day tests and is imperative when 24 hour tests are required. Another similar error is to specify that test specimens intended to check the quality of the concrete are to be given the same weather exposure as the structure during the time the specimens are kept on the job, whereas the A.S.T.M. specification requires that they are to be kept moist and at substantially 70 F during the interval before reaching the laboratory; in fact it is further suggested that a heated box may be necessary for storing the specimens during cold weather in order to meet the temperature requirement. This feature of a special storage box is seldom found even on large projects.

There is need for greater care in keeping specifications posted to conform with the current A.S.T.M. issue, and this is especially true in localities whose recently revised building codes provide for "current A.S.T.M. standards" as applying.

Time of placing

A long outmoded provision which still appears in some specifications is a requirement that concrete shall be placed within 30 minutes after mixing or after the cement comes in contact with water. An important government agency which has named this provision for many years recently liberalized its requirement for time interval between mixing and placing to the following:

"Concrete shall be placed before initial set has occurred and, unless otherwise authorized by the contracting officer, before it has contained its water content for more than 45 minutes."

If in the past there was any justification for such a blanket limitation, the vast experience with ready-mixed concrete in the last 15 years has proven it entirely unnecessary. The successive A.S.T.M. tentative and standard specifications under designation C 94 have for years stated that an elapsed time of 1½ hours is reasonable, but have suggested

further that longer or shorter times may be specifically authorized. Some of the references in commercial specifications to an interval of 30 minutes seem to imply that at that limit a sudden transformation occurs whereby the concrete is immediately ruined for use. The provision of such a limitation suggests either unfamiliarity with the characteristics of concrete under normal conditions or stubborn adherence to former practices. It should be recognized that fresh concrete, at reasonable temperatures, stiffens slowly for several hours and that during most of this plastic period the actual placeability of the concrete increases. Any requirement of a short interval between mixing and placing appears unjustified; on the other hand, there is much evidence to indicate that an interval of over ½ hour will contribute to a reduction in the shrinkage during setting.

Bin-test of cement

On much modern construction, especially when other projects besides the one under specification are being supplied concrete from one source, as a commercial ready-mix plant, it seems futile to require bin-test reports from the cement manufacturer for the cement ordered for the single project alone. The use of bulk cement in such operations is becoming general. In such cases if cement tests are to be required, either all of the cement passing through the concrete plant, which would include that used in the given project, should be "bin-tested," or there should be a test of a representative sample of the cement passing through the mixing operation on the days of delivery to the given project. A common practice of filing with a project a number of "bin-test" reports on the number of carloads represented in that job is purely artificial as it is impossible to establish that the cement from those particular cars, and none other, actually entered a given structure. The specification for the given project should not be based on any assumption that cement for the project can be segregated when it is manifestly impractical to do this at many of the commercial operations supplying concrete in metropolitan areas.

A somewhat similar problem results from the occasional requirement that cement for a large project shall be stored by the manufacturers in "sealed bins," and that such cement shall not be shipped to other than that project. This provision places a hardship on the manufacturer as it ties up storage facilities when they may be needed for general trade, and during a period of short supply the shortage may be aggravated by withholding from the market a substantial quantity of cement in a sealed bin. If the project is being served through a commercial batching or ready-mix plant handling cement in bulk, the complete segregation of cement from a sealed bin through the stages of handling and into the job requires either additional storage and handling equipment which is

seldom available, or suspension of deliveries to all other trade on days that project is being serviced.

Storage of cement

An example of an apparently handed-down and unrevised specification was noted recently in a requirement written by the architect-engineer on a large war plant under rushed construction. This specification provided—"The cement is to be delivered on the site at least two weeks before it is required for use, to allow time for testing." As this project would consume some 1500 bbl. of cement daily for several weeks, the contractor installed a large mixing plant equipped to handle bulk cement; this requirement for storage, if enforced, would have meant providing at the job silos with a capacity of over 20,000 bbl. Here again, if there was ever any justification for such a provision, there appears no need for it today and modern construction methods would not permit such procedure. The inclusion of such an impractical provision tends to weaken other items in the specification as doubt is raised as to whether there will also be laxity in enforcing other provisions.

Air entrainment

The growing practice in recent years of requiring or accepting appreciable amounts of entrained air in concrete is bringing out some inadequate provisions. It is sometimes stated that "this concrete shall contain entrained air" or that "air-entraining concrete will be accepted," without any provision as to the amount of air. Apparently some specification writers have not realized that normal structural concrete, mixed with regular portland cement, contains about 1 percent of entrained air; also, that with the most common interground aerating agent, the temperature of the mix, the grading of the fine aggregate; and other factors will influence the amount of air in the final mix, and that if the entrained air is to be obtained by adding an admixture at the mixer the amount of air (with detergent type of materials) will depend on the quantity of admixture used. Hence, for a specification covering air entrainment to mean anything it should state definite limits for the amount of air in the concrete being placed and there should be provision for checking on the amount of air present. Inadequate provisions may result in an excess quantity which might reduce the compressive strength greatly, or less than desired with consequent sacrifice of the benefits expected. Until the characteristics of air entrainment are better standardized than at present, the provisions as regards air should be stated definitely and not be left to chance.

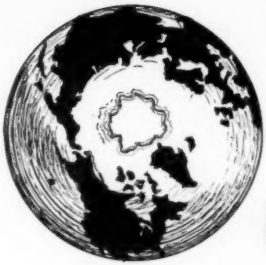
Quasi-legal language

Another practice which does not refer to the technical provisions as such, but which may still be questioned from the standpoint of the

realities, is a tendency to word the specification in a jargon of quasi-legal language. Clauses such as "the performance shall be as the engineer may require" lead only to confusion. A specification should comprise a straight-forward, explicit statement of the physical features to be accomplished. Even though it may be anticipated that the document might become the basis of legal action, there is no occasion to attempt to express its requirements in the redundant and involved language which characterizes many legal instruments, and which sometimes serves to confuse the actual objectives. It appears adequate and preferable to express a specification for concrete in the definite terms of good "engineering English."

CONCLUSION

Other instances could be cited of provisions in specifications which are not fully realistic. Most of the items mentioned in the foregoing discussion result from one of two classes of errors: (1) inadequate understanding of the physical characteristics of concrete, or (2) inclination to continue using ready-written provisions without revision for local conditions or changes in approved standard requirements. If those who must comply with specifications, as well as those who write and enforce them, will note these and other typical shortcomings, there should be a rapid elimination of provisions which might be subject to criticism. The writing of specifications for concrete merits greater study and attention by many of those preparing them. The correction of any unrealistic feature of a specification will contribute toward improving the efficiency of handling the construction involved.



Letters from Readers*

BY WAY OF SYNOPSIS

PAUL G. VAIL describes a method for determination of free moisture in aggregate using a pressure type air entrainment indicator.

C. G. ODEN describes a construction project that used precast facing units as exterior forms.

A reader asks for information on the effect of carbon dioxide on concrete strength with a partial answer from the Editor.

M. J. HESS discusses rustproofing of reinforcing steel.

E. AHLSTEDT presents additional information on cellular concrete.

NORMAN A. GRANDAGE and E. COPELAND SNELGROVE supply more information on air entrained in concrete.

Use of Pressure Type Air Entrainment Indicator for Aggregate Moisture Tests (LR 46-33)

PAUL G. VAIL, Civil Engineer, Office of the District Engineer, Dept. of the Army, Detroit, Mich., describes a method for field determination of free moisture in aggregate.

An accurate and expedient method for field determination of free moisture content in concrete aggregate has been found in using a pressure type air entrainment indicator as a moisture meter, supplanting the Chapman flask and drying methods.

The indicator is normally used in controlling entrained air in the concrete for the new hydro-electric power plant at Sault Ste. Marie, Mich., and suggested itself as a possible alternate method for moisture determination in aggregates, permitting the use of much larger test samples to obtain quicker and more representative results.

*A part of copyrighted JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, V. 21, No. 3, Nov. 1949, *Proceedings*, V. 46. Separate prints are available at 35 cents each. Address 7400 Second Boulevard, Detroit 2, Mich.

A sample of about 35 lb of either fine or coarse aggregate can be tested in the indicator as compared to one lb of fine aggregate in the Chapman flask. A test can be run in about five minutes as compared to the 30 minutes required for drying a small coarse aggregate sample for moisture determination.

Before adopting the use of the indicator, several check tests were run by the drying method from the same test samples. The two methods invariably checked within 0.2 of one percent in moisture content. Moisture resultant values are giving design mix slumps in the field without any water correction. To date, around 200 moisture tests have been made with the air indicator for control in the pouring of approximately 7000 cu yd of concrete.

Although the air indicator should not be compared with elaborate devices as may be used on large-volume concrete work, it is believed that the method described deserves consideration for small jobs in view of the dual use of the indicator.

Procedure

The volume of the indicator is determined by filling with water to the zero mark in the glass tube and weighing.

Wt. of indicator, filled with water	88.23 lb
Wt. of indicator, empty	56.58 lb
Wt. of water	31.65

$$\text{Vol. of indicator, } \frac{31.65}{62.4} = 0.508 \text{ cu ft}$$

The approximate size of the test sample may be determined by filling the bowl separately and weighing. In this case a sample of 35 lb could be tested.

With the weight of the test sample fixed (35 lb) the corresponding total weight of the aggregate, water and indicator is determined for the aggregate in a saturated surface dry condition, representing zero percent free moisture:

Wt. of aggregate sample (SSD) ..... 35.00 lb

$$\text{Vol. of aggregate sample, } \frac{35}{2.78 \times 62.4} = 0.202 \text{ cu ft}$$

Note: The calculations, graph and tabulated figures are for a 0.44 cu ft bowl. The sand used had a specific gravity of 2.78 and an absorption of 0.7 percent. The coarse aggregate (stone) had a specific gravity of 2.82 and an absorption of 0.4 percent.

The values given are for bulk specific gravity, determined by A.S.T.M. Method C 128-42. The specific gravity of coarse aggregate was determined by immersing a 5000 gram sample, 1-in. size from 2-in. size gradation screening, in water for 24 hours to obtain the highest amount of absorption. The individual rocks were then brought to a SSD condition by wiping with an absorbent cloth, the sample immediately weighed, placed in a wire basket and immersed in water for loss of weight determination. The same procedure as above was followed with another sample to determine absorption except that after weighing, the sample was oven dried to a constant weight, cooled to air temperature in the oven and then weighed.

The specific gravity of sand was determined by first obtaining 24 hour absorption, then bringing the sample to SSD condition by stirring with warm air blowing over it. Five-hundred grams were then placed in the Chapman flask for specific gravity determination and 500 grams were oven dried to obtain absorption.

Vol. of water to fill, $0.508 - 0.202$.... = 0.306 cu ft
Wt. of water to fill, 0.306×62.4.... = 19.10 lb
Wt. of indicator..... = 56.58 lb
Total wt. representing a 35-lb sample SSD..... 110.68

In a like manner compute the total weight for a sample containing 7 percent free moisture.

Wt. of 35-lb sample containing 7 percent moisture when reduced to saturated surface dry condition, $35.00 - (35.00 \times 0.07)$..... = 32.55 lb

Vol. of sand, $\frac{32.55}{2.78 \times 62.4}$ = 0.188 cu ft

Vol. of water (surface moisture plus that required to fill indicator), $0.508 - 0.188$ = 0.320 cu ft
Wt. of water, 0.320×62.4..... = 19.97 lb
Wt. of indicator..... = 56.58 lb
Total wt. representing a 35-lb sample containing 7 percent free moisture.. = 109.10 lb

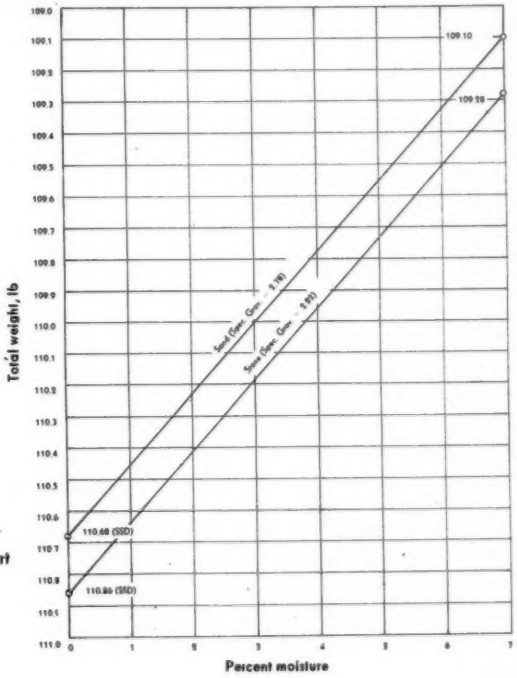


Fig. 1—Moisture test chart

Plotting these two points on a graph, Fig. 1, determines a line from which the percent moisture can be read directly for all test samples, since the specific gravity, indicator weight and volume are constant.

A line for determining free moisture in coarse aggregate can be similarly determined.

For testing the moisture content of sand, fill the bowl about one-third full of water. Stir small amounts of sand in the water, tapping the sides of bowl. The sand should be kept inundated, adding more water as needed. Fill the bowl to near the top after the sample is contained. Clamp the cover on (3 clamps sufficient) and add water to about half way in the glass tube. Tap the cover lightly, rotating the indicator. Add water to zero reading and weigh. Read percent free moisture corresponding to this weight from the chart.

The stone sample may be weighed in the bowl with the sides of the bowl being tapped lightly while water is added to near the top. The remainder of test is the same as for testing the moisture content of sand.

Precast Facing Slabs Used as Exterior Forms (LR 46-34)

C. G. Oden, Oden Construction Co., Jackson, Miss., describes the use of precast units as exterior forms.

We recently completed an office building for the Concrete Research Division of the Waterways Experiment Station, near Jackson, Miss. The building is a two story structure with full basement as an addition to the laboratory building.

We encountered the usual problems in underpinning and details of construction but this job varied from the usual in that thin precast concrete facing units were used as the exterior forms for an otherwise conventional concrete frame.

Wood forms for the inside face of columns and spandrels and a partial return around the sides of the columns and bottom of spandrels were first erected in place together with the metal pan floor system. The precast concrete facing units were then set, forming the other portions of the columns and beams, by tying through the wood forms with adjustable ties fastened to anchors cast in the facing units. In erecting this part of the formwork extreme care was necessary due to the lack of tolerance permitted in ordinary concrete frames. Since the wood centering, to which the facing units were tied, moved the units with changes in the weather, constant realignment was necessary.

The facing units were true to dimension, did not chip easily and together with the ties were adequate to withstand the pressure of vibrated

concrete. The facing units between the columns above the spandrels were backed-up with hollow clay tile. These units were erected after removing the column and beam forms and were then followed by the vertical and horizontal window mullions, which fitted accurately with ¼-in. joints.

Curing Concrete with Carbon Dioxide (LR 46-35)

A reader wants data on the effect of carbon dioxide on concrete strength.

I have been told that concrete cured in the presence of carbon dioxide shows greater strength and durability. Any information, or references to papers treating this subject in detail would be appreciated.

In "Length Changes of Cement Paste in Relation to Combined Water," ACI JOURNAL, Sept.-Oct. 1937, *Proc.* V. 34, p. 25, Yashichi Yoshida said:

"One of the products of the combinations between water and cement is calcium hydroxide. If this calcium hydroxide is exposed to carbon dioxide from the air or water surrounding the paste, calcium carbonate is formed. . . . The carbonation of exposed surfaces of concrete in normal service may extend inward for distances of the order of one inch. Under moist conditions it is of value in protecting marine structures against the corrosive action of sea water, but under dry conditions it may be the major cause of crazing . . . carbonation is appreciable even under the condition of moist storage (in fog) and that under the extreme condition the amount of combined carbon dioxide equals 25 percent of the weight of the cement. Other things being equal, the carbonation is greater for higher water-cement ratios, for longer periods of exposure, for earlier ages of exposure to drying conditions, and for lower humidity of the air. Presumably the carbon dioxide content of the atmosphere would influence the rate and amount of carbonation, but this factor was not studied in the investigation . . . in larger masses of concrete the effect of carbonation will be confined largely to the region near the surface. However, this region is particularly important with regard to surface cracking and weathering; and it (is) believed that increased attention to the role of carbon dioxide in volume change is justified."

Further references are Clyde R. Hutchcroft and Harvey R. Anderson, "The Use of Carbon Dioxide to Reduce Efflorescence on Asbestos-Cement Shingles," ACI JOURNAL, Apr. 1941, *Proc.* V. 37, p. 597, and A. J. Gaskin, "The Effect of Carbon Dioxide," *Bulletin* No. 229, Council for Scientific and Industrial Research, Commonwealth of Australia (Melbourne). The latter is summarized as follows:

"Expansion and spotting of mortar due to cement-aggregate reaction can be inhibited by treatment of the mortar with carbon dioxide. Active alkali hydroxides, produced by hydrolysis of the cement particles, are thereby converted to carbonates, which are inactive in contact with most aggregates. Where carbonation is sufficiently advanced, enough protective calcite is formed to confer permanent immunity from expansion and spotting on the mortar, although no appreciable improvement in tensile strength could be obtained."

Additional comments by readers are invited.—Editor

Rustproofing Reinforcing Steel (LR 46-36)

M. J. HESS, Engineering Dept., Wilson and Co., Inc., Chicago, Ill., asks about the rustproofing of reinforcing steel.

We have all seen spalled concrete on the bottom of slabs, in columns and beams exposed to moisture, etc. We know that until prestressed concrete is more common we cannot avoid cracking in the concrete cover, so moisture is sure to get to the reinforcing rods and the resulting rust will eventually cause spalling.

Is it advisable to use some method like Parkerizing or Bonderizing in rustproofing reinforcing steel?

I realize that rustproofing means increased cost of reinforcing steel, but on the other hand, Gunite repairs are also expensive, at times inconvenient to make and not always 100 percent satisfactory.

A contractor friend advocates the painting of rods with red lead, especially in footings, but we believe that this procedure is not recommended. What is the recommended procedure?

Gas Concrete and Perlite For Lightweight Concrete (LR 45-20)*

E. AHLSTEDT, International Ytong-Stabalite Co., Stockholm, Sweden, gives additional information on gas concrete in response to an inquiry in the June JOURNAL.

We noticed your reply to Mr. Gengelbach in the June JOURNAL and also noticed that you would like to have more comments concerning "gas concrete."

For more than 20 years lightweight concrete, or *gasbeton*, has been produced in Sweden using bituminous shale ash and lime with aluminium powder as the foaming agent. The material is manufactured in three different bulk densities, *viz.*, 40, 30, and 25 lb cu ft. Slabs with a bulk density of 25 lb cu ft are used as insulation for concrete structures; blocks and slabs of the higher densities are used for masonry walls and partitions.

We also call to your attention a recent publication by Prof. Otto Graf of the Technical University of Stuttgart.† His booklet gives some very interesting data on various types of cellular concrete and recent developments in both Germany and Sweden.

In Sweden, housing construction uses approximately 17½ million cu ft of cellular concrete or lightweight concrete as you call it. The amount

*See ACI JOURNAL, June 1949, *Proc.* V. 45, p. 742.

†Graf, Otto, *Gasbeton, Schaumbeton, Leichtkalkbeton*, Versuchsergebnisse und Erfahrungen, Stuttgart, 1949, reviewed in Current Reviews, ACI JOURNAL, Sept. 1949, p. 87.

of brick used in Sweden is approximately the same. A lightweight aggregate was once on the market but is seldom used now.

What Is the Difference Between Air Entrained in Ordinary Concrete and That Resulting from an Air-Entraining Agent? (LR 45-22)*

NORMAN A. GRANDAGE and E. COPELAND SNELGROVE, Marsden, Huddersfield, England, supply further information on the question asked in the June JOURNAL.

The query posed by Anton A. Anjel suggests the following explanation.

The extended use of surface active agents in concrete practice necessitates a better precision in language than is, at present, in vogue. Possibly if the physical facts are set out, the language may be allowed to adjust itself. All the ingredients of a concrete mix in their separate states contain air, 30 to 50 percent in the stones, sand and cement, and a relatively minute amount in the water.

Normal concrete

During mixing, approximately 7/8 of the air escapes. The remaining portion, possibly 5 percent of the whole mass, is in the wet concrete as it leaves the mixer.

At the time of placing, this 5 percent will be further reduced according to the type of compaction, punning or vibration, employed. The final residue of air remains in the form of relatively large bubbles scattered at random throughout the mass. At the same time, in normal concrete, much more water is employed than that necessary only to hydrate the cement. When the concrete sets and dries out, the excess water on its departure (by drying) leaves channels, runlets and capillaries roughly linking up with the air bubble cavities. Hence, normal concrete provides the conditions for fairly easy permeation by fluids, and in consequence is vulnerable to the attack of frost and chemicals. The abovementioned story is subject to wide variations, according to the proportions and character of the ingredients employed.

Plasticized concrete

Precisely the same account holds good for concretes mixed with the addition of a surface active agent, except that the final residue of air, remaining in the concrete will be in the form of minute noncommunicating bubbles spread uniformly throughout the mass. Since surface active agents are applied to the formation of two distinct types of concrete, the story must here divides to tell of each separately:

*See also ACI JOURNAL, June 1949, *Proc.* V. 45, p. 747 and Sept. 1949, *Proc.* V. 46, p. 68.

Dense plastic concrete—The proportions of ingredients should be such that (1) there is a minimum of excess water beyond that needed for hydration of the cement; (2) the amount of air finally left in the concrete will be 4 to 5 percent and it will be all in the form of minute noncommunicating bubbles, uniformly distributed throughout the mass.

Consequences (given suitable proportions) of such a mix are that the small amount of excess water is largely used up in forming the skins of the numerous bubbles. There is no water remaining in runlets which on drying out could provide capillary connections between bubble cavities.

Lightweight concrete (given suitable proportions)—As the sand, cement, water and surface active agent proportions are increased, and the stone's fraction reduced, more and more air may be brought into the minute bubble form. There is now more water for making bubble skins and and the larger number of fine particles provides more spaces to put bubbles into.

For both dense and lightweight concretes, when the air is in the form of minute bubbles uniformly spread throughout the mass, integral with the concrete, it is called *entrained air*. There should be no other air in a concrete carrying the due proportion of surface active agent.

Air entrainment would, therefore, appear to mean the act of causing air to become an integral part of the concrete by dividing it into minute bubbles and spreading it evenly throughout the mix (placing it under control). Any other air is haphazard air.

Vibration and punning—Entrained air will stand a good deal of vibration of a low order, but continued vibration with high frequencies and small amplitudes may drive out even the tiniest bubbles.

Current Reviews*

of Significant Contributions in Foreign and Domestic Publications

Building on made-up ground or filling

Digest No. 9, Building Research Station, Watford, England. 4pp.

Leads are given on the factors to be considered in assessing the suitability of an existing fill and the design of foundations for buildings on this type of ground. The placing of new fill to provide optimum support in a short time is considered.

Vermiculite (Les vermiculites)

R. M. LECLERC and R. RINCK, *Cahiers du Batiment* (Paris), No. 50, July 1949 pp. 1-15

The authors give an over-all and well documented picture of the present understanding of this new material and also of its possible application to insulation and fireproofiing of buildings. This article also contains the results of various recent experimental tests.

Filling and sealing materials for joints in concrete roads

Road Note No. 7, Road Research Laboratory, Dept. of Scientific and Industrial Research (London), 1949. 11 pp. 15 cents

Based on widespread field observations supplemented by laboratory tests recommendations are given on the filling and sealing of joints in concrete pavements. The three types of joints commonly used are illustrated, spacings of joints for winter and summer conditions are suggested and the composition and uses of fillers and sealing compounds are given in detail.

Determination and use of the dynamic modulus of elasticity of concrete

EDMUND F. PREECE, *Proceedings*, Highway Research Board, V. 28, 1948, pp. 233-237

The dynamic modulus of elasticity of portland cement concrete may be used to forecast the probable 14- or 28-day flexural modulus of the concrete when the specimen is but a few days old. Extensive use of the procedure has led to practical developments, reported in this paper, which somewhat simplify the procedure and greatly reduce the labor required.

Concrete components (Composition des betons)

P. GENDRE, *Cahiers du Batiment* (Paris), No. 52, July 1949, pp. 1-9

This article first reviews the operations to determine the proportion of cement, aggregates and water, according to methods used. The author describes concrete tests on

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site, particularly direct measures, and the quantities of water incorporated in fresh concrete samples. No account is taken of granulometry of aggregates and on the contrary, he determines the contexture of concrete using aggregates as they come on the building site.

Production of portland cement of moderate strength: II

SHOICHIRO, NAGAI, *Journal of the Japanese Ceramic Assn.*, V. 49, No. 588, (1941), pp. 745-50

CERAMIC ABSTRACTS Sept. 1949

Tests were made to obtain a mixed cement of low price and moderate strength by mixing the following substances with the portland cement clinker: (1) coal ash, (2) slag rich in *MgO*, (3) slag from phosphorus production, and (4) white clay from Koan, Manchuria. Substances 1, 3, and 4 can be used, but 2 is not suitable. Coal ashes having high-soluble silica and alumina contents are the best.

New materials and nontraditional methods of construction (Materiaux nouveaux et des procedes non traditionnels de construction)

Cahier du Batiment (Paris), No. 52, July 1949, pp. 1-24

Prefabricated reinforced concrete wall sections and systems of incorporating them into a structure, concrete blocks, wall and floor forms, precast concrete beams and floor systems of seven types, and a precast thin partition panel of lightweight concrete are illustrated and described. The limitations of each are noted and recommendations are made for proper use in building construction in France.

Practical form problems (Seen from the point of view of the contractor)

H. H. KARNOV, *Ingenioren* (Copenhagen), V. 58, No. 19, 1949, pp. 403-408

Reviewed by EIVIND HOGNESTAD

The paper presents a short description of various parts of formwork most commonly used in Denmark and their advantages and shortcomings.

The most important points which the supervisor should keep in mind are outlined, and the use of mechanical equipment is mentioned. The necessity of rationalization due to scarcity of skilled labor and the difficulties related to the piece-work system are stressed.

An economic survey and comparison between wood and steel forms is presented, followed by a general discussion of problems pertaining to concrete forms.

Industrial minerals and rocks

American Institute of Mining and Metallurgical Engineers (New York), 1948, 2nd. Edition, 1156 pp. $8.00

In 51 chapters by recognized authorities this completely revised edition contains condensed information and data on nonmetallic minerals other than fuels ranging from abrasives to vermiculite. Information is given on the geological classification of each mineral, the types and kinds of commercial importance, origin and distribution of deposits, production methods and preparation for market, specifications, marketing uses, and prices. Prospecting and exploration methods are given for many of the minerals.

The U. S. Geological Survey, U. S. Bureau of Mines, and the Canada Dept. of Mines and Resources are the sources of much of the statistical and other data. A bibliography in each chapter enhances the reference value of the book by pointing the way to further information.

Of particular interest to those primarily concerned with cement and concrete are the chapters on cement materials, crushed stone, heat and sound insulators, pumice and pumicite, sand and gravel, and vermiculite.

Cavitation-free inlets and contractions

HUNTER ROUSE and M. M. HASSAN, *Mechanical Engineering*, V. 71, Mar. 1949, pp. 213-216

APPLIED MECHANICS REVIEWS Sept. 1949 (Crandall)

The use of the analogy between the flow of electric current in a wedge of uniform electrolyte and the irrotational, axisymmetric flow of an incompression fluid, to facilitate the design of conduit inlets and contractions, is described. If the boundary of the wedge is geometrically similar to the conduit wall profile, the analogy yields values of the pressure at the conduit wall from measurements of the electric resistance between points along the wedge boundary. A family of elliptic-arc inlet profiles and a family of cubical-arc contraction profiles were studied to obtain cavitation-free designs, that is, flows with no local pressure minima along the conduit wall.

Control of variations in quality of concrete and its effect on mix proportions

F. N. SPARKES, Road Research Laboratory, Department of Scientific and Industrial Research (London), Feb. 1949

HIGHWAY RESEARCH ABSTRACTS Sept. 1949

Concrete is a variable material and variations in quality are usually referred to in terms of the compressive strength of test cubes. This paper indicates the factors contributing to this variation and attempts to assess their relative importance, and so to deduce the nature of the improvement effected by their control in the field.

The probable variation in concrete strength caused by quality of concrete, aggregate grading, bulking of fine aggregate, batching methods, compaction, mixing and transporting, temperature and other factors are summarized. Variations in concrete quality may be expressed as the ratio of the minimum strength to the average strength, and the closer this approaches unity the more uniform and the more economical will be the concrete. A number of ratios are suggested as a reasonable assessment of the effects of control.

Self-shrinkage of concretes by expanding cements

H. LOSSIER, *Memorial de societe ingenieur civils France*, V. 101, No. 3-4, 1948, pp. 189-225

CERAMIC ABSTRACTS Sept. 1949

Expanding cements are those that permit control of expansion and shrinkage in any direction, especially tridimensionally. They are obtained by mixing a portland cement, a sulfoaluminous cement, and a stabilizing element. By correct proportioning of the three constituents, intensity and duration of the expansion can be controlled exactly. The principal types are slightly expanding (nonshrinking) cement with an initial expansion of 3 to 4 mm per m in the pure paste, just enough to counteract the natural shrinkage, and greatly expanding cement with an expansion of the paste of 10 to 25 mm per m. The duration of the expansion can be regulated between 10 and 15 days. The intensity of expansion of the concrete decreases with the content of expanding cement; designating the expansion of the pure paste as unity, the expansion of a concrete with 1000 kg per cu m of cement will be about 0.90, with 800 kg—0.70, with 600 kg—0.45, with 400 kg—0.20, and with 250 kg—0.10. Present status of development, experiences of 13 years, and examples of application in different structures are described in detail.

Washington method of determining air in fresh concrete

BAILEY TREMPER and W. L. GOODING, *Proceedings*, Highway Research Board, V. 28, 1948, pp. 210-218

The pressure method of determining air in fresh concrete has many advantages. In the Washington method the pressure principle is used in a somewhat different manner from that commonly employed. A chamber containing air is connected through a

valve to a sample of concrete in a sealed container. With the valve closed, air is forced into the chamber to a measured gage pressure. When the connecting valve is opened, the gage pressure drops to a value dependent on the air content of the concrete.

Advantages of the method are: (1) in common with other pressure methods, no weighing is necessary and the percentage of air in the sample can be read directly, and (2) compared to other pressure methods, the apparatus is more compact, determinations are made more rapidly, no water is used, corrections for barometric pressures are not needed, and calibrations can be made readily in the field over the full usable range of air contents.

Construction of the device and auxiliary apparatus is illustrated. Test data shows it to be accurate. The operation is easily understood and has been used successfully by inspectors on construction work without personal instruction.

Discover new-type cement, Norwegians say

Foreign Commerce Weekly, Vol. XXXVI, No. 4, July 25, 1949 . HIGHWAY RESEARCH ABSTRACTS Sept. 1949

Calcite, a metamorphic limestone, appears to give concrete unusual water-and acid-resistant qualities. Engineer Arne Daniels of the Vaagsoy Cement Works in Sunnmore recently presented results of a series of tests which indicated that four parts of cement to one part of calcite mixed into concrete forms a building material highly resistant to salt water, weather, and acids.

Several years ago, while examining concrete installations in the tidewater section near Vaagsoy he discovered a cement dock built in 1913 which showed no indications of water action. Investigation proved that the fishermen who built it had unknowingly mixed calcite into the concrete. During the past 2 years, a series of laboratory experiments have indicated that calcite may in reality be the key to a highly efficient building material. Whether the new ingredient will, for example, make it possible to use calcite-concrete instead of glazed tile pipe in acid soil, or to effect other savings in increased durability of dams, wharves, and exposed structures, will depend on results of on-the-job tests extending over a period of many years.

Compressive strength, and its relation to the water-cement ratio and the age of the concrete (Resistencia de rotura a la compresion en funcion de la relacion agua/cemento y de la edad)

ALBERTO S. C. FAVA, *Publicacion del Laboratorio de Ensayo de Materiales e Investigaciones Tecnologicas* (La Plata, Argentina), Series II, No. 29, 1948, 108 pp. Reviewed by FRANCISCO J. CORDOVA

This report is the first part of a series of technical investigations made by Fava on the properties of concrete. It shows the results of laboratory tests performed with the ultimate purpose of determining the influence of the water-cement ratio and the age of the concrete on its compressive strength.

For this investigation three different brands of Argentine cement were used. The fine aggregate consisted of siliceous sand from the Uruguay River. The coarse aggregate was crushed granitic rock from Sierra Chica, Province of Buenos Aires. The water-cement ratio of the concrete mixture varied from 0.35 to 0.98 by weight.

All aggregate tests, chemical analyses of the cement, and autoclave expansion tests were made according to the A.S.T.M. The plastic mortar strength tests were made according to the I.P.T. of Sao Paulo, Brazil. Other physical tests on the cement were made according to standard Argentine specifications.

The report also describes methods for testing, equipment used, and the criteria adopted for the application of the method of least squares in determining the constants used in the various equations.

The results of the tests are shown by means of numerous tables, graphs and computations.

Prestressing applied in bound columns (in English)

W. Olszak, *Arch. Mech. Stos.*, V. 1, 1949, pp. 80-98

Applied Mechanics Reviews Sept. 1949 (Wierzbicki)

The idea of introducing initial compressive stresses into brittle materials when under bending or tension is successfully employed in modern structural engineering. The author presents an interesting and somewhat unexpected extension of this idea to axially loaded, helically bound columns. The problem is solved as one of the theory of elasticity involving the analysis of an "transversally orthotropic" model. Initial prestressing of the spirals reduces the contraction as well as the lateral expansion of the concrete core and raises the crushing load of the column, as based on the Caquot-Mohr criterion of rupture. The coefficients of increase in the crushing load are the higher: (a) the higher the quality of steel, (b) the lower the quality of concrete, (c) the higher the ratio of lateral compression to longitudinal compression. These effects are obtained with low and medium percentages of binding which generally occur in practical design. They do not apply to very lightly and very heavily bound columns.

The author's basic conclusions are in agreement with the results of experimental data obtained by G. A. Maney.

Cost of form materials

C. Grambye, *Ingenioren* (Copenhagen), V. 58, No. 17, 1949, pp. 365-367

Reviewed by Eivind Hognestad

It is difficult to check the number of times each wooden member can be re-used in formwork. Thus it is proposed to consider the amount of waste timber as a significant quantity influencing the cost of form materials. This quantity can be checked after each job, since it is the difference between the amount of timber brought to the job and the amount of usable timber brought from the job.

The cost (p) of materials per unit of contact area can be written:

$$p = m\, t_n\, \mu$$

where m = amount of timber in cu ft per unit contact area

t_n = price of new timber per cu ft delivered on the job.

$$\mu = \frac{s}{100} + \frac{0.5}{n}\left(1 - \frac{s}{100}\right)$$

where s = percentage of waste, *i. e.*, the total amount of waste in relation to the total amount of timber required if the complete structure had to be completed in one erection of formwork.

n = number of erections on the job.

The accuracy of an estimate depends on the knowledge of costs of similar work on previous jobs. As (s) can be checked after each job the author feels that estimate and actual cost can be brought closer together by the method outlined above.

The "Zofra" elastic concrete sleeper (El durmiente "Zofra" de hormigon elastico)

Zorislav Fpanjetic, *Hormigon Elastico* (Buenos Aires), V. 2, No. 1, Jan. 1949, pp. 20-26

Reviewed by Alberto S. C. Fava

The author points out that ordinary reinforced concrete railway sleepers, under dynamic railway loads, break and are useless after a short time. He mentions the tests of Emperger (*Beton und Eisen*—1943) on prestressed reinforced concrete railway sleepers, and points out that the Swiss Federal Railway used them successfully. Furthermore, according to the author, the experiments of the Federal Research and Testing

Institute of Materials in Zurich (EMPA), have proved that prestressed reinforced concrete is adaptable to the manufacture of sleepers.

Several troublesome points were fastening the rail to the sleeper, correct industrial manufacture, and prestressing of the reinforcement both in the longitudinal and transverse directions. These problems were solved by using the "Zofra" system which permits reinforcement of transverse sections subject to the greatest loads, and which are at the same time weakened by the holes drilled for fixing the rails.

The Zofra sleeper has a hollow trapezoidal transverse section with a concrete wall thickness dictated by the applied loads. The weight is approximately 330 lb. The base of the sleeper is corrugated for increasing the resistance against lateral movements. The degree of prestressing of transverse and longitudinal reinforcement is determined as a result of static calculations.

According to the author, the real technical advantage of the Zofra sleeper rests in the possibility of reinforcing the weakest sections by prestressing the transverse reinforcement (steel wires) in a simple and economical way.

The lateral pressure exerted by concrete during casting

J. Brineh Hansen, *Ingenioren* (Copenhagen), V. 58, No. 16, 1949, pp. 341-343

Reviewed by Eivind Hognestad

This paper analyzes the various theoretical means of determining the pressure exerted by fresh concrete on forms. Six different formulas are considered, four of which are well known whereas the last two were developed by Christiani and Nielsen.

All formulas are applied to about 50 experimental results described in the literature. A comparison shows that Shunk's method is uneconomical, giving results which are too much on the safe side. Noack's formula is dangerous, being practically always considerably on the unsafe side. Ljungberg's and Macklin's method seem likewise to be rather unreliable, and this applies also to the simple formula given in the *Concrete Manual* of Christiani and Nielsen. However, the more complex formula developed by this firm seems to give considerably less scattering than any of the other formulas, when compared with the test results considered. This latter formula has the following form:

$$P = \frac{0.36\gamma t_s}{\left(1 + \frac{0.08}{v}\right)^3} \cdot \frac{1 - e^{-\frac{u}{8F}}}{\frac{u}{8F}} \cdot \left(\frac{3.6}{b+c} + 0.4\right)$$

The maximum concrete pressure (p) is here given as a product of 3 factors. The first contains the specific gravity (γ), the setting time (t_s) and the pouring speed (v). The second expresses the silo-action, as (u) is the circumference and (F) the area of a horizontal section through the form. For infinity large area this silo-factor equals one. The third and last factor corrects for the mix-ratio which is assumed to be $1{:}b{:}c$. For a ratio 1:2:4 this factor equals one.

Some investigations of the effects of core size and steel and concrete quality in short reinforced concrete columns

J. W. H. King, *Magazine of Concrete Research* (London), No. 2, June 1949, pp. 47-56

Author's Summary

The work described is a continuation of earlier work on short concrete columns, which had as its object the determination of the effect of lateral reinforcement on column strength. It was clear from this earlier work that relative core size would be likely to have a significant effect on strength, and the present investigations were initiated primarily to examine this.

On the assumption that the currently accepted formula for helically bound columns had some justification for taking as one of its terms "core area by concrete strength," it was believed that high quality concrete would demonstrate the effect of core size better than a more ordinary concrete and a series of tests was carried out in this way. As the tests failed to indicate any marked effect, columns were made with normal concrete and high quality steel. To round off the work a third group was made of normal quality steel and concrete.

In the main, binders were of a normal square type and a materially constant strength, but a few were of modified shapes.

As a result of the tests it has been possible to formulate general conclusions concerning the effect of core size, cover thickness, concrete and main steel strength, and core shape, to confirm the general conclusions of earlier work that binder contributions to strength was proportional to $1/\text{pitch}^2$ and to indicate that there is a material advantage in using high quality steel as main reinforcement.

Actual test loads are compared in the tables with loads calculated by a formula derived from the earlier tests, where core area was a constant proportion of the column area (51 percent), where concrete strength was sensibly constant, and where main steel consisted of various sizes of normal black bar. The significance of the various changes is thus revealed more clearly.

High grade steel as reinforcement in concrete beams (Nogvardigt stal som armering i betong balkar)

BJORN ORBOM, *Bulletin* 103, 1948, Statens Provningsanstalt, Stockholm. 46 pp.

Economical use of high grade reinforcement steel requires that permissible reinforcement stresses be fixed as high as possible. This is limited by the difficulties of anchoring the bar ends in the concrete so as to provide sufficient safety against anchorage failure. As the crack width in concrete increases with increasing reinforcement stresses, irrespective of steel grade, the risks of dangerous cracks are relatively great when using high permissible reinforcement stresses. Anchorage and crack formation were of special interest in this investigation, carried out at the Government Testing Institute, Stockholm, comprising tests of 88 concrete beams reinforced with four types of high grade steel reinforcement bars, all with a minimum yield point of 4000 kg per sq cm.

The different methods of anchoring the reinforcement are described and an anchorage casing constructed by C. Forssell for plain bars and used in some of the beams is illustrated.

Some beams were tested with continuously increasing static load while others were tested with static as well as pulsating load. The limit reinforcement stresses of the pulsating tests were 200-300 kg per sq cm (lower limit) and half the yield point or half the stress at failure for corresponding beams tested with static load (upper limit). The total number of pulsations of a beam was 25,000.

The ratio of reinforcement and diameter of bar have some effect on the crack width. The surface properties of the reinforcement did not influence crack width at reinforcement stresses lower than 300 kg per sq cm, when the beam was loaded statically. For beams tested with pulsating load and the use of 14-mm diameter deformed bars instead of plain bars give a clear reduction of the crack width. The failure of most beams was caused by slip of the bar ends.

The pulsating load often caused an intermittent slip of the bar ends but never anchorage failure, except for some of the beams reinforced with 12-mm diameter plain bars without end hooks or 22-mm diameter deformed lug and helical bars without end hooks.

The influence of bar diameter and length of embedment on anchorage strength is indicated and the deflections of the beams for reinforcement stresses lower than 3000

kg per sq cm are shown in diagrams giving the deflections of corresponding beams reinforced with bars of different surface properties from which it can be seen that beams reinforced with deformed bars generally have as large deflections as beams reinforced with plain bars, when reinforcement stresses are the same.

The calculation of girders resting on soil—the modulus of soil reaction, K (in French)

E. E. DeBeer, *Annales Travaux publics Belgique*, V. 101, 1948; June, pp. 393-413; Aug., pp. 525-552; Oct. pp. 653-691 Dec., pp. 721-749

Applied Mechanics Reviews Sept. 1949 (Quintal)

The classical method for solving reaction patterns under a footing is to assume that the footing rests on an infinite number of columns, the deformation of which is in direct ratio to the reaction according to the law $p = Ks$, where p is the reaction and s the settlement. The author shows that this method, neglecting a vertical shear in the soil, is analogous to considering the soil a heavy liquid. The Schiel-Wieghardt modification is shown to be similar to the classical method with superficial tensions added.

The author proves that both methods are erroneous and proposes instead to solve the problem by successive approximations of the deformation of the footing and of the soil. The soil is considered both heterogeneous and anisotropic but in such a way that its modulus of elasticity varies according to depth; thus the stress at any point and in any direction due to a concentrated load may be found by using Frohlich's and Buisman's formulas, and may be found by combining them with Newmark's diagram for a distributed load. The settlement at the surface of the soil is then considered as the sum of the elementary settlements under the point considered and may thus be linked to the stresses.

In some cases it may be possible, by integration, to find an equation for the reactions which will apply both to the elastic curve of the footing and to the soil surface, but in most cases it is necessary to start with a given reaction pattern and proceed by successive approximations until a fair agreement is reached. Numerous problems are treated as examples, and a series of tests performed to estimate the precision of the method, are described in detail. It is shown that for long beams a fourth-degree parabola coupled with a logarithmic function will give a very accurate reaction diagram if the soil corresponds to the Rhine sand used in the tests, while a second-degree parabola will usually give results more accurate than those from either the classical or the Schiel-Wieghardt theory.

In dealing with soils for which one of the basic assumptions does not hold, for instance those which have a Poisson's ratio not equal to 0.5 or a modulus of elasticity not proportional to the stress, the final simplifications do not apply, but the method is still valid and could be used in a number of practical problems.